SCIENCE

15 September 1961

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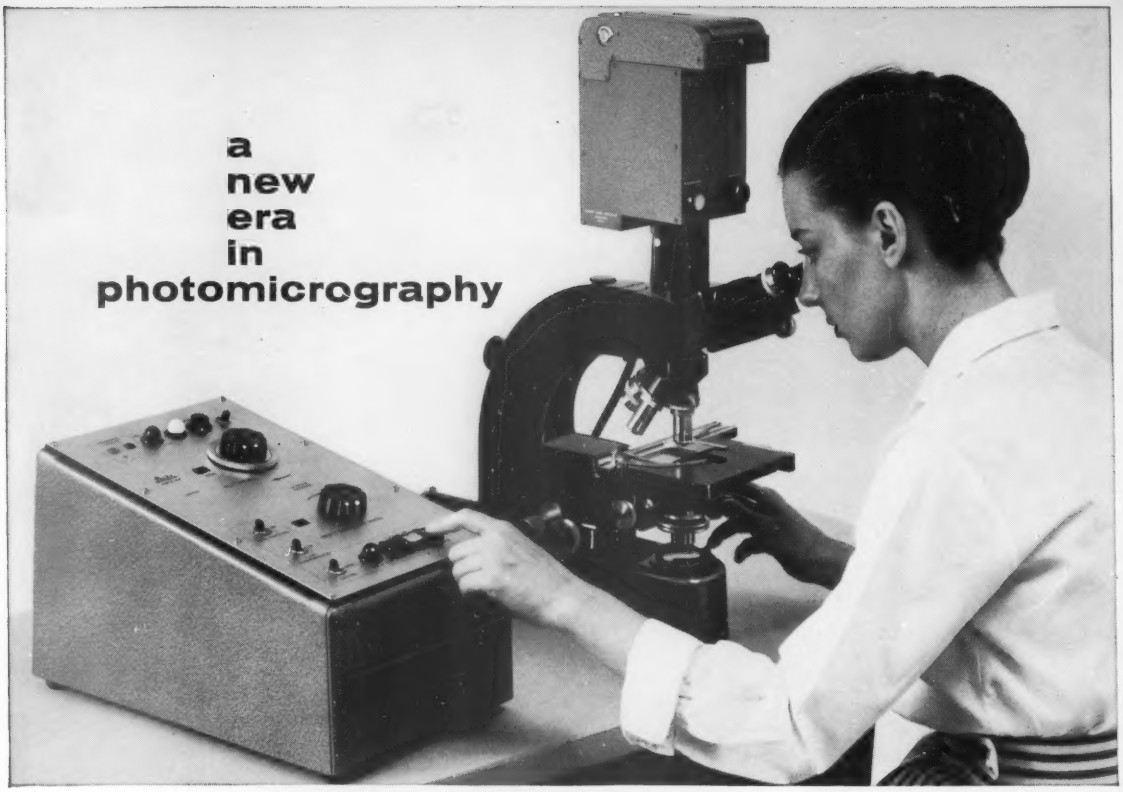
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



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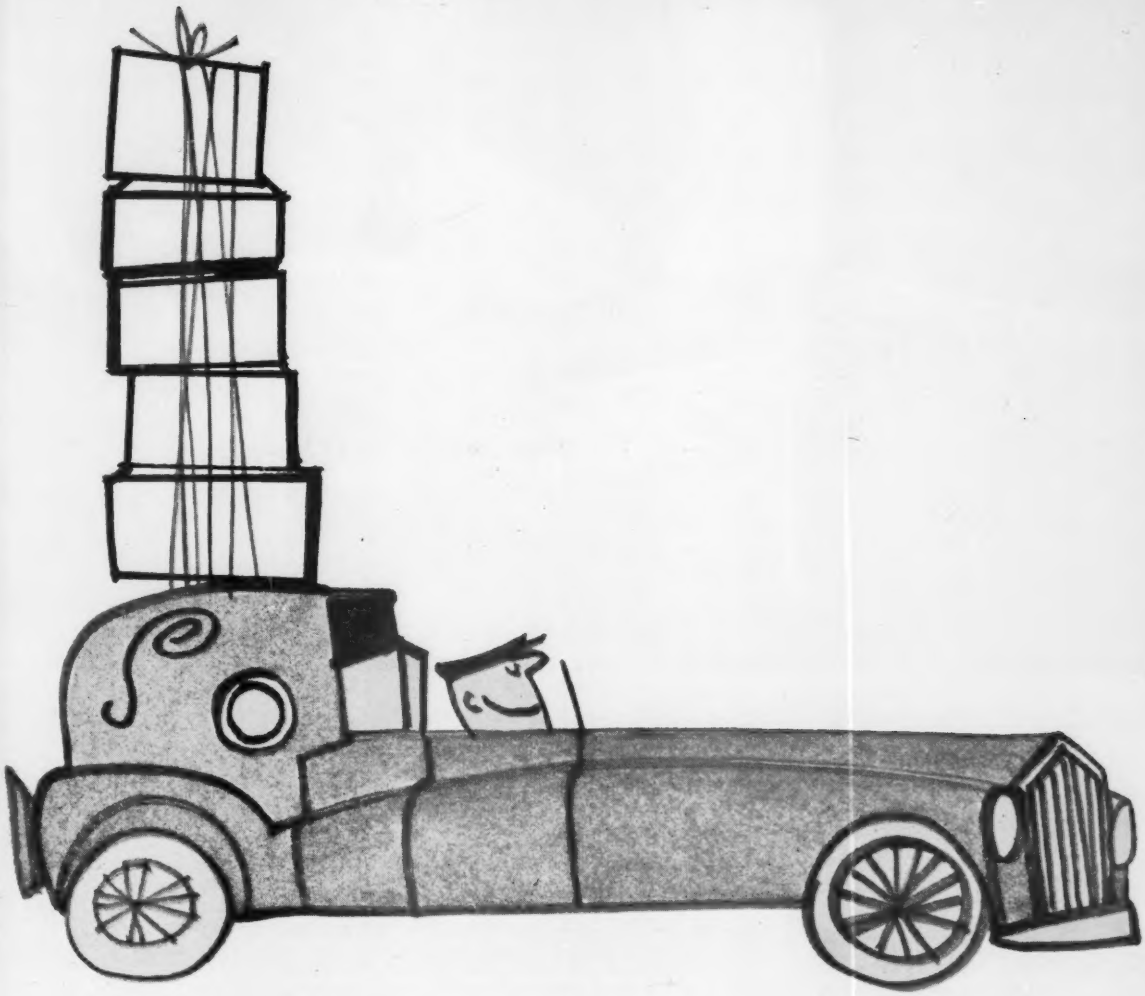

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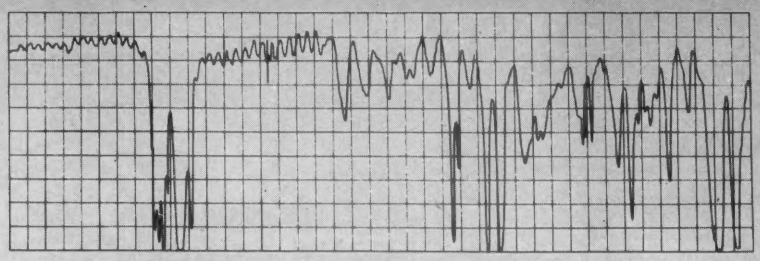

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15 September 1960, Volume 134, Number 3481

SCIENCE

Cover

Silver drinking bowl of Phoenician design found in the tomb of a 7th-century B.C. Etruscan prince. In the outer frieze the prince is seen leaving the palace gates in a chariot, hunting deer, picnicking at midday, being attacked by hairy giants, and being rescued by Astarte, patroness of chariots. Afterward, he returns home. From *Dawn of Civilization*, reviewed on page 723. [McGraw-Hill, New York, 1961]

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Program Content

1. The two-session AAAS General Sessions, "Moving Frontiers of Science," Part I—Speakers: Howard A. Meyerhoff and Arthur R. von Hippel; Harrison Brown, presiding. Part II—Speakers: Halton C. Arp and E. W. Fager; Harrison Brown, presiding.
2. The 29th John Wesley Powell Memorial Lecture. Speaker: Glenn T. Seaborg; Paul M. Gross, presiding.
3. On "AAAS Day," the four broad, interdisciplinary symposia—Physics of the Upper Atmosphere; Geochemical Evolution—The First Five Billion Years; Existing Levels of Radioactivity in Man and His Environment; and Water and Climate—arranged by AAAS Sections jointly.
4. The Special Sessions: AAAS Presidential Address and Reception; Joint Address of Sigma Xi and Phi Beta Kappa by Harrison Brown; the Tau Beta Pi Address; National Geographic Society Illustrated Lecture; and the second George Sarton Memorial Lecture.
5. The programs of all 18 AAAS Sections (specialized symposia and contributed papers).
6. The programs of the national meetings of the American Astronomical Society, American Society of Criminology, American Nature Study Society, American Society of Naturalists, American Society of Zoologists, Beta Beta Beta Biological Society, Biometric Society (WNAR), National Association of Biology Teachers, Scientific Research Society of America, Society for General Systems Research, Society of Protozoologists, Society of Systematic Zoology, and the Society of the Sigma Xi.
7. The multi-sessioned special programs of the American Association of Clinical Chemists, American Astronautical Society, American Meteorological Society, American Physiological Society, American Psychiatric Association, Association of American Geographers, Ecological Society of America, National Science Teachers Association, National Speleological Society—and still others, a total of some 70 to 80 participating organizations.
8. The sessions of the Academy Conference, the Conference on Scientific Communication, and the Conference on Scientific Manpower.
9. The sessions of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, of the AAAS Committee on Science in the Promotion of Human Welfare.
10. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
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Letters

National Science Academy Bill

There is one bill being considered by Congress that has not received as much attention in the scientific community as it deserves. It is HR-1, a bill to establish a national science academy, several research institutes, a scholarship and fellowship program, and a separate career service for government scientists. Enactment of the bill would considerably strengthen science in the United States.

Establishment of the academy would make more and better qualified scientists available for government research positions. The curriculum would include both graduate and undergraduate courses, but it is to be hoped that emphasis would be put on the graduate courses. The provision of research institutes in which the faculty would participate is wise for many reasons. Not only would it keep the faculty fresh and abreast of current problems but it would provide federal research centers, outside the Department of Defense, in several needed areas. Institutes of oceanography and meteorology are specifically provided for, and there would be others as determined by the director. A healthy mixture of teaching and research would help to attract a highly qualified faculty and would produce superior graduates for teaching or research. The bill provides that federally supported students would be obligated to spend as many years in government scientific service as they spent at the academy, unless other provisions were made by the director of the academy. It has already been suggested that acceptance of a teaching position in any U.S. school should be considered an acceptable alternative.

The proposed program of scholarships and fellowships at existing universities and colleges is an excellent one. These can be administered from any or all of several existing organizations, but they could be handled without any suggestion of bias from a national science academy.

The proposal to establish a distinct scientific career service within the Civil Service is sound and worthy of support, but separate from the proposal to establish an academy. It is part of the over-all effort to improve the lot of the scientist in the federal government, however.

Scientific freedom, so essential in a university, would certainly exist in a national science academy. The present National Science Foundation testifies to that. The graduate science academy with research institutes could produce scientists as competent as those trained by older methods, if not more competent, and it would produce more of them.

HR-1 is still being studied by subcommittee No. 3 of the House Committee on Science and Astronautics. Representative Victor Anfuso of New York is the chairman.

WILLIAM CARTER

2904 Garth Road,
Huntsville, Alabama

Exporting Universities

The very stimulating editorial entitled "Diploma diplomacy" [*Science* **133**, 1557 (1961)] has very wisely emphasized a point made by A. F. Burns regarding the establishment of universities on foreign soil with American government funds. It should be pointed out that the American University of Beirut, the largest "American" university outside of the United States, is essentially an existing example of what Burns suggests. However, that university is privately endowed largely with American private capital.

Although it is impossible to overemphasize the amount of good will for the United States that this university and its graduates have spread in the Middle East, this institution is not looked upon with fond regard by all in the host country. The annual budget of A.U.B. ($2 to $3 million) is approximately equal to the total annual budget for all public education in Lebanon. Several years ago Lebanon established its own national university within its Department of Public Education. Most people would resent foreign teachers of their elementary and secondary grades and many feel the same way about university-level instruction. While American professors abroad do feel the pulse beat of the people to a greater extent than any other group of Americans abroad, they also catch the strong, indignant reactions of the host country to American foreign policy actions. If the A.U.B. may be taken as an example, it should be noted that its good name rests on its reputation of many years of unselfish service to the Arab nations.

Professors' salaries are about one-half to one-third their U.S. equivalents, and the universities have infinite patience with obstacles that stand in the way of a proper education. It goes without saying that most secondary school graduates in underdeveloped countries do not have sufficient preparation to enter a university. It also goes without saying that we would be hard put to find U.S. professors to lecture in a foreign tongue, and lecturing in English is considered one form of propaganda. I do not think you could find much Peace Corps fervor for this program in U.S. professorial circles.

These remarks are not made against so-called "diploma diplomacy." On the contrary, the idea has a sound basis. Having taught at A.U.B. for 3 years I would like to encourage the idea but dissuade anyone who feels that this is an overly easy way to help an underdeveloped country with American capital.

JAMES R. HEIRTZLER

Lamont Geological Observatory,
Columbia University,
Palisades, New York

As a former student at Robert College, Istanbul, Turkey, may I voice my support of the editorial "Diploma diplomacy." The establishment and support of colleges on foreign soil, such as those of the Near East Colleges Association in Greece, Turkey, and Syria, has been an excellent example of America at its best.

Whether private or government aided, such institutions provide the educational facilities and the contact with live Americans so sorely needed. It also avoids costly maintenance of students in a far-off place, and reduces the threat of draining underdeveloped countries of their scientific man power.

HERBERT A. SCHNEIDER

146 Circle Drive,
Millington, New Jersey

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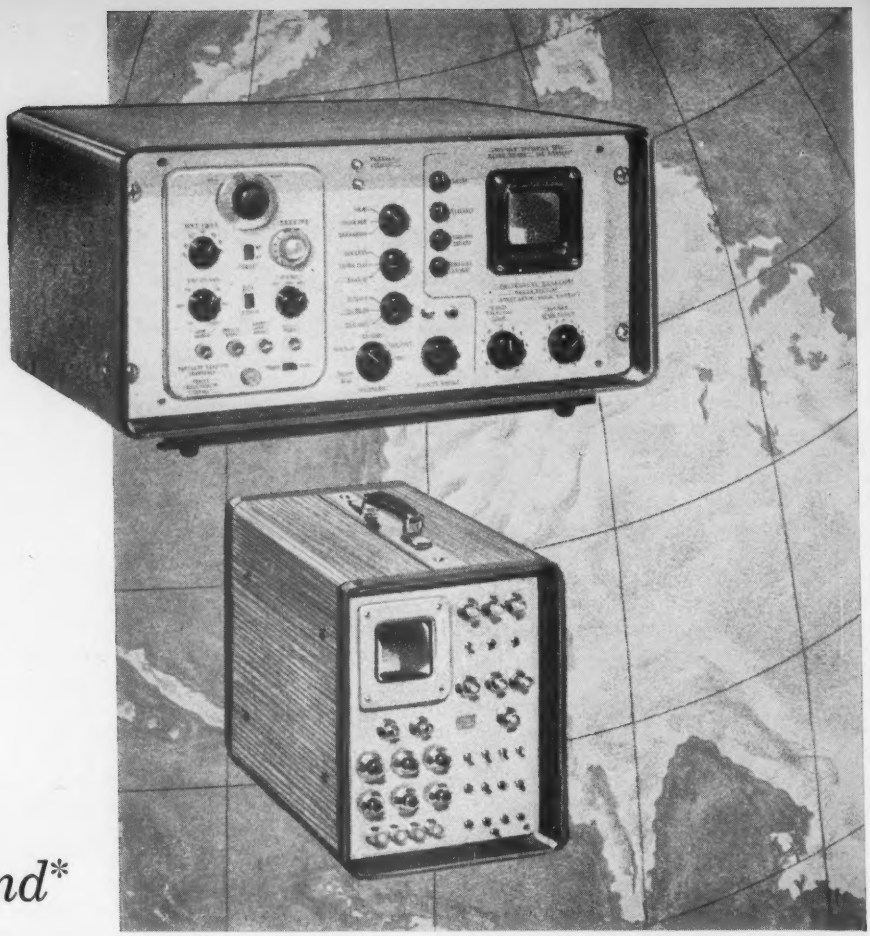

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SCIENCE

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Terror and Talks

Through the course of the ugly developments during the past few weeks, the Soviet Embassy in Washington, D.C., has continued to keep its front lawn properly watered. Had the lawn been allowed to lapse into the condition of the desert across the street fronting the National Geographic Society, there would be even greater cause for concern over Soviet policy. We can expect Soviet representatives to remain in Washington for a while. We can expect talks about talks, and even talks.

There is other evidence besides the Embassy lawn that one aim of the resumption by the Soviet Union of atmospheric testing of nuclear weapons is to promote, albeit in a special way, East-West negotiations. In fact, from the very beginning, Khrushchev has made no secret of this aim. In an interview with two members of the British Labor Party shortly after the announcement that there would be renewed testing, Khrushchev said that he hopes, by developing a superbomb with a force of 100,000,000 tons of TNT, to shock the Western powers into negotiations on general disarmament and Berlin. Consider also Khrushchev's 13-page reply to the West's reiteration of its proposal for a treaty banning atmospheric testing. True, after referring to his government's "aching heart" over resuming testing, Khrushchev rejects the proposal, but a man does not bother to reject at such length unless he wishes to give his opponent something more to talk about.

Negotiations based on shock, to be sure, would be on terms more congenial to the Soviet Union than negotiations conducted without shock, such as might otherwise have taken place. As for neutral nations, because of the Soviet move they might now see more clearly than ever before that the Soviet Union is the country threatening world peace. But the gamble, already paying off, is that renewed testing will cause neutral nations to bring pressure on the West to meet Soviet demands, just because world peace is so seriously threatened.

The absence of a great outcry by neutral nations against the Soviet Union has been a source of surprise and chagrin in this country. We continue to learn that judgments rendered by neutral nations upon us and upon the Soviet Union are characterized by a certain lack of symmetry. Nevertheless, our decision to keep postponing the resumption of underground testing, even in the face of the Soviet's blatant reneging on gains that had been achieved at the Geneva talks, still appears to have been exactly right. We are now in an incomparably better position regarding world opinion, even given this lack of symmetry, and regarding our opinion of ourselves, than we would be in if we had announced new underground explosions and the Soviets had immediately responded, as we now see they were prepared to do, with their present testing program.

If one aim of the Soviet resumption of atmospheric testing is to terrorize the rest of the world, then one aim of Kennedy's announcement, after the third Soviet bomb went off, that we would resume testing underground, is to show firmness in the face of this attempt. Here, as in all dealings with Russia, American strategy for minimizing the likelihood of war is to avoid the extremes that characterize Soviet maneuvers. We cannot afford to appear threatening, for that might invite the Soviet Union to strike us out of fear that we are planning a first strike ourselves. At the same time, we cannot afford to appear conciliatory, for that would invite miscalculation of the extent of aggression we can permit.—J.T.

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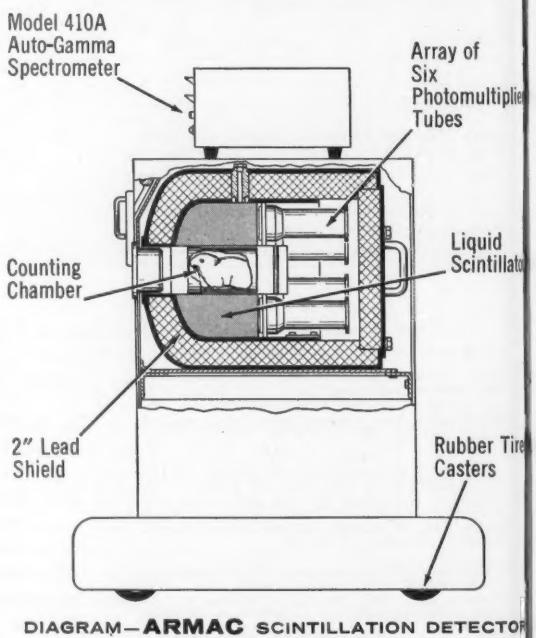

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15 September 1961, Volume 134, Number 3481 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Reef Building

The growth of living breakwaters has kept pace with subsidence and wave erosion for fifty million years.

Harry S. Ladd

Whether one first sees a reef from the sea or from the air, one cannot but be impressed, not so much by the beauty of the curious structure as by its ability to withstand the force of the waves that ceaselessly break upon its seaward edge. It has been estimated that normal waves dissipate 500,000 horsepower—one-fourth the power generated at Boulder Dam—against the windward side of an open sea atoll (*1*). How can lowly plants and animals build a structure to withstand such forces? Actually, the forces of storm waves are many times as great, and though the reefs are damaged by storms, they do survive. Furthermore, as has been demonstrated, some of them have survived for as long as 50 million years. These structures are truly worthy of an engineer's respect.

Since the earliest days of navigation, mariners have known reefs at first hand and have feared their power to break up ships. The venturesome Lieutenant (later Captain) James Cook was wrecked on the Great Barrier Reef in 1770 and had to careen the *Endeavour* for extensive repairs before continuing his first globe-encircling voyage (*2*). Captain Henry Wilson, whose ship the *Antelope* was wrecked on a reef in Palau in 1783, was less fortunate. He and his crew had to build a new ship before proceeding homeward (*3*). Another famous explorer, La Pérouse, like his contemporary Captain Cook, was making a scientific expedition around the world when both of his frigates, the *Astrolabe* and the *Boussole*, were lost, in 1788, on the dangerous outer reefs of Vanikoro in the Santa Cruz Islands (*4*).

The Christian missionaries, who closely followed these early Pacific explorers, also had their difficulties in navigating under sail. The missionary ship *Duff*, in the midst of a lengthy voyage among the islands of the southwest Pacific, struck a reef in the little-known waters of eastern Fiji. She struck at night but managed to back off, leaving nothing to the reef but her name (*5*). The mission schooner *Harrier* was not so fortunate on the Great Barrier Reef (Fig. 1).

In 1890 there was a disastrous wreck on a reef in Torres Strait, near Thursday Island. The British India liner *Quetta*, of 3484 tons, bound from Brisbane to London with 293 persons aboard, was passing through Adolphus Channel, a reef area believed to have been adequately charted. Steaming through calm waters on a bright moonlight night she struck a flourishing coral pinnacle rising from 13 fathoms and sank within three minutes, with a loss of 133 lives. Sixteen years later divers blasted a porthole from the sunken ship's side, which had been thickly overgrown with coral. The charts available to the *Quetta* in 1890 were based on surveys made between 1802 and 1860, and it is possible, although not probable, that the pinnacle that ripped open two-thirds of the ship's bottom had grown sufficiently in the years that followed the surveys to become a menace to navigation after the charts were made (*6*). Atlantic reefs also have taken their toll (Fig. 2).

Storms, inadequate charting, poor night visibility, and faulty navigation have all played parts in driving ships onto reefs, but one large modern tanker lies rusting on a Pacific atoll for a different reason. During World War II she entered the deep narrow pass leading to a lagoon where much of the U.S. Fleet was stationed. The tanker was loaded with fuel for the fleet but had not been given proper identification signals, and those in charge of security were loath to clear her. She was ordered to turn back, even though this was obviously impossible in the narrow reef pass. To this day the reef organisms near the site of the wreck have not fully recovered from the oil bath that followed.

Reefs, however, are constructive as well as destructive. Some of the finest tropical harbors are protected by natural breakwaters in the form of reefs (Fig. 3). In Ceylon attempts are now being made to stimulate and control coral growth in binding artificial breakwaters (*7*).

Reef lagoons and atoll islands were used as stepping-stones and way stations by early Polynesian voyagers, who eventually sailed their outrigger canoes all the way from Indonesia to the high volcanic islands of Hawaii. Trading vessels of all sorts found safe anchorage in lagoons in the years that followed. During the Pacific campaign of World War II, protective reefs played a most important role in island defense.

Appearance of a Reef

What does a reef look like? At high tide nothing may be visible but a line of white breakers, possibly with a band of green water behind it. At low tide, in areas where tides have a range of several feet, the broad reef flat may be awash or actually out of water, revealed as a brown band. Part of the surface

The author is affiliated with the U.S. Geological Survey, Washington, D.C., in the Branch of Paleontology and Stratigraphy.

may be a smooth sand flat on which one could ride a bicycle, and I have seen planed rock pavements so smooth that one could—though I have never tried!—go about on roller skates. More often, tide pools, microatolls, and areas of short-branched or knobby coral heads make up parts of the surface. Water-filled pools help give a deceptive appearance of levelness.

The Builders

All wave-breaking reefs in the tropical seas are commonly called coral reefs, though both biologists and geologists have known for more than 50 years that on many reefs the calcareous algae are the essential, and in some places the most abundant, contributors. The corals exhibit greater variation in form and color than do the lime-secreting algae, and this diversity is doubtless responsible for the ease with which they won first place in the eyes of early observers (Fig. 4). The tips of many graceful staghorn corals are brilliant blue or violet; other palmate corals are bright pink or claret, yellow, green, or brown; most massive hemispherical colonies are more drab, but in some each corallite of the honeycomb surface contains a central "eye" of fluorescent green. When the colonies are intermingled in a pool or are cemented at various angles on the wall of a reef channel the effect is striking, to say the least.

Algae, on the other hand, are mostly shades of brown, yellow, or purple, and a single type of uniform shape and color will dominate a given area of a reef. Along the seaward edge the buttresses between channels may be covered almost entirely by pink or purplish globular colonies, and the result, though colorful, is unvaried; the encrusting type of algae may form a flattish pavement uniformly brown or yellowish-brown in color.

These two groups—the corals and the algae—are the important reef builders. The corals add bulk, the algae function as cementing agents. Among numerous minor contributors are the Foraminifera, both encrusting and benthonic types. The latter, though small individually, live in such abundance on reef flats that their shells, carried shoreward by the waves, form the bulk of the sands of the beaches that fringe reef-encircled islands.

Occurring widely, but in lesser abundance, are many other invertebrates—echinoids (sea urchins), mollusks, and tube-secreting worms. These minor groups may also function as agents of reef destruction. Locally, certain types of boring echinoids occur in tremendous numbers and may literally riddle a rock pavement solidly built by corals and algae. Several types of worms and clams bore into coral heads, both living and dead. When broken open, many corals are seen to be pierced by holes and to resemble a Swiss cheese. Other destructive borers include algae, sponges, and barnacles.

Wave-Resisting Features

The amounts of calcium carbonate taken from sea water to build a reef are impressive. At Eniwetok Atoll, for example, the limestone mass (reef complex) that caps the volcanic foundation contains more than 250 cubic miles of limestone; practically all the limestone was secreted by shallow-water organisms. The most noteworthy feature, however, is not the volume but the fact that parts of the mass of skeletal material are so constructed or so cemented that the reef can grow upward to low-

Fig. 1. Wreck of the New Guinea mission schooner *Harrier* on the Great Barrier Reef of Australia. [Courtesy W. H. Allen and Co., Ltd.]

tide level and maintain itself against wave attack. How is this accomplished?

Three distinct elements or processes are involved: (i) the growth forms of the builders, which enable them to construct an efficient baffle that, in addition to bringing a constant supply of refreshing sea water to all parts of the organisms, robs the incoming waves of much of their force by spreading the water in all directions; (ii) cementation by the organisms to the foundation on which they grow and to each other; (iii) lithification of sediments, probably an inorganic process, which takes place beneath reef flats and at intertidal levels on shore. The first two processes are well understood, the third is not.

Growth forms. The algae and corals that flourish along the margin of a reef exhibit two dominant growth forms. Some grow as thin veneers that do not break the force of the waves but do function efficiently as cementing agents. Others build spongelike structures that are so porous or intricately branched that the force of the oncoming wave is diverted and spread widely in many directions. The surface densely covered by such colonies acts like blotting paper.

The baffle effect, efficiently performed by the individual colonies along the margin, is repeated on a larger scale by major reef structures developed in the same area. The grooves and buttresses of the "toothed edge" (Fig. 5) concentrate the power of the oncoming waves into trenches, some of which lead through the marginal zone as surge channels below the reef surface (*8*). The lower part of each wave attempts to enter caverns below the reef surface. The resistance encountered in these already filled chambers absorbs some of the waves' power; another part is absorbed by spouting, geyserlike blow holes and by thousands of tiny holes in the pavement behind the marginal ridge. With each incoming wave water oozes upward through this sievelike pavement. The caverns beneath the reef margin have not been studied in detail, but enough is known to justify comparison with the well-known "room-and-pillar" caverns of mining operations.

Organic cementation. Encrusting calcareous algae (*Porolithon* and other lithothamnia) function effectively as enveloping lamellar growths that bind loose fragments to the growing reef edge, and they may even smother colonies of living coral. These organisms flourish in a constant supply of moving water, and they form a fairly solid pavement on the back slope of the marginal ridge, where weakened surges pass landward and where other water wells upward through the porous reef structure. Many of the corals along the reef edge also adopt the veneering habit, forming a living calcareous blanket that, when opportunity permits, may extend itself over areas of living algae. I have measured single colonies of veneering coral that extend for 30 feet along the reef margin.

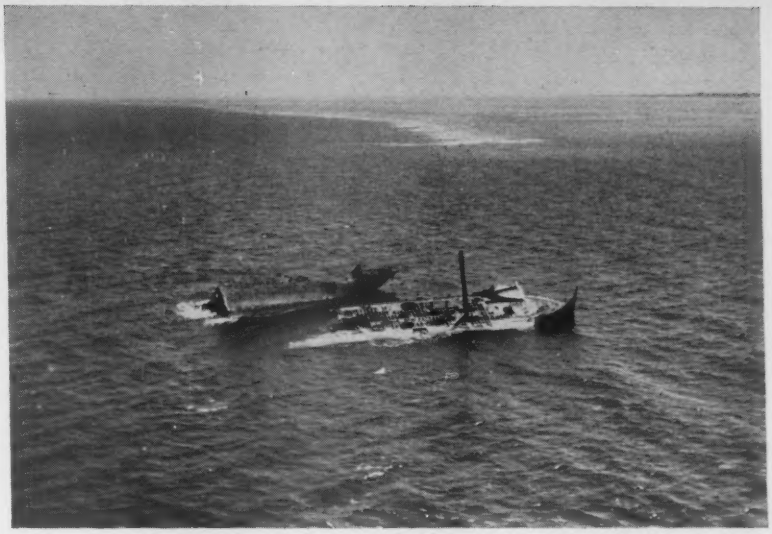

Fig. 2. Wreck on Andros Island reef, in the Bahamas. [Fritz Goro, *Life*]

Lithification. From the standpoint of reef stability and the development of wave-resisting qualities the reef margin is the crucial area. In this area organic binding seems to be the important process, but in other parts of the reef—on the wide flats behind the margin and even on the beaches—other processes of cementation occur. These bind the sediments of the flat and the sands of the beaches into fairly hard rock. The processes are probably chemical, in large part.

Current Problems

Much of the present-day interest in reefs began shortly after Pearl Harbor, when we lost Guam, Wake, and the Philippines. We planned to recapture these reef-encircled islands and to occupy many others captured or long held by the Japanese. This planning, and our early attacks such as that at Tarawa, revealed how little we knew about reefs and the waters surging over them. Special reports summarizing all available information, hastily prepared for the Armed Services, were of some assistance, but it was not until after the war that intensive field investigations of reefs and reef islands were undertaken as part of military terrain studies. These studies, supported by the Army and carried out by U.S. Geological Survey personnel, coupled with the intensive reef studies made at Bikini and nearby atolls in the Marshall Islands, supported by the Armed Forces and the U.S. Atomic Energy Commission, have given us the sort of reef information that we lacked during the Pacific campaign of World War II.

Somewhat earlier—in the late 'twenties and 'thirties—oil was discovered in large quantities in certain ancient reefs. These discoveries continued after the war (*9*) and greatly stimulated reef work in general. A third factor that dates from the war years is the increase in activity in the fields of oceanography and marine geology.

Seaward Margin of the Reef

The most vital part of a reef is the marginal zone along the windward side. This is the zone where living organisms are concentrated, and it is the site of the most persistent wave attack. The remainder of the reef is largely dependent upon this zone, which is the place where building must take place if the reef is to flourish and expand. An understanding of growth processes in the windward marginal zone is an essential part

Fig. 3. The reef-protected harbor of Suva, Fiji. The entrance is through Levu passage, which breaks the barrier on the left. [Rob Wright, Fiji official photograph]

of the story of reef building. Ironically, this is the zone least accessible to direct observation. Problems and questions still remain to be solved and answered.

The zone of marginal growth, as here defined, consists of three distinct parts. The first is a ridge of living algae that rises above the reef flat and may be widely exposed at times of low tide. It is cut at fairly regular intervals by surge channels (Fig. 5). The next is a zone below low tide on the seaward slope, which consists of deep grooves separated by wide buttresses. This is the "toothed edge" so clearly visible from the air (Fig. 6). The lower part, at least, is a zone of rich coral growth, possibly the richest of all, that extends downward to the ends of the longest grooves at about 50 feet below sea level. This zone is so inaccessible that it has been dubbed the *"mare incognitum."* A third zone, in the moderately illuminated waters below normal wave base, at depths of 50 to 150 feet, is a zone where corals of a somewhat different type grow in abundance, but it has been only superficially explored by dredging (*10*).

The submarine "toothed edges" of most windward reefs have been described from many areas. The patterns, so sharply marked on air photographs, have been observed somewhat more closely by swimmers. As yet, however, because of hazardous sea conditions, no one has succeeded in making a detailed examination at close range. Most workers, I among them, have regarded the groove-and-buttress system as primarily constructional, the buttresses being due to organic growth. Others believe that the grooves have been excavated by erosion and that growth is a relatively unimportant factor (*11*). The work being done by Thomas Goreau on the reefs of Jamaica supports the belief that the buttresses are constructional and is impressively documented (Fig. 7) (*12*). Newell *et al.* (*13*) described and illustrated closely spaced furrows or grooves from the Bahamas. As these are cut in oölitic country rock they certainly were *not* formed by growth. They may be due to erosion, as Newell and his associates suggest, but conceivably they could have been formed by solution when the sea stood lower. In any event, they do not closely resemble the typical grooves found off existing reefs in the Pacific. Cloud noted what appeared to be similar grooves in the face of a basalt-floored bench in Hawaii (*14*) but stated that he had not studied them. If the typical grooves are primarily erosional it is remarkable that they are well-nigh universal off windward reefs yet rare in other types of rock. It seems to me quite possible that improved diving techniques will eventually settle this most interesting problem.

SCUBA diving by reef students may also permit a closer examination of the growth zone immediately below the *"mare incognitum."*

Rate of Growth and Other Problems

Direct examination of exposed sections of elevated reefs and examination of samples obtained by drilling have shown that corals and other builders have persisted for long periods of time, long even when reckoned geologically. The calcareous skeletons left by one generation are superimposed on the skeletons of earlier generations, eventually accumulating thick deposits of limestone. The rate at which this rock-building takes place is of prime interest, and numerous attempts to measure it have been, and are being, made. The bulky skeletons of sessile corals lend themselves to measurement, though, as Vaughan pointed out, they are not ideal subjects (*15*). Vaughan made thousands of measurements of growth on 25 species, both naturally growing and artifically cemented to terra cotta or concrete disks fixed to iron stakes driven into the sea bottom. Mayor (*16*) measured the growth of corals in Samoa; Edmondson (*17*) did so in Hawaii. The late T. A. Stephenson and his wife Anne carried out well-organized and exceedingly valuable growth studies of several sorts on the Great Barrier Reef (*18*). One of the corals measured by the Stephensons is shown in Fig. 8. A number of fine studies of coral growth have also been made by the Japanese (*19*).

In 1960 J. Edward Hoffmeister began a long-term study of the Florida reef tract. His project includes growth experiments on reef corals similar to those mentioned above. Hoffmeister planted his first corals on the edge of the reef near Key Largo, an area lying between Dry Tortugas and the Bahamas where Vaughan made earlier studies. In addition to measuring growth rates on corals in their chosen environment Hoffmeister is transferring colonies from one environment to another to determine the effects of such changes.

The growth rate of individual colonies of coral is, of course, only an indirect measure of the growth rate of the reef surface. Estimates of the percentage of the reef surface covered by various species have to be made, and several types of losses have to be estimated and deducted. An over-all figure for reef growth, based on coral measurement, is probably less than 14 millimeters per year. This figure is comparable to estimates based on the measurements of organic productivity by Sargent and Austin (*20*) and by H. T. Odum and E. P. Odum (*21*).

The plant and animal communities that live on reef surfaces have long excited the interest of marine biologists, as attested by a voluminous literature. Several thousand organisms that live on reefs have been named and described, and much attention has been given to the life habits of the builders and of the organisms whose activities destroy reef rock. These studies have been carried on, and are being carried on, at biological laboratories established in reef areas and by special expeditions sent out to study reef problems. Examples are the comprehensive work done by (i) the British on the Great Barrier Reef of Australia, particularly the work of the expedition of 1928–29 under the leadership of C. M. Yonge (*22*); (ii) the laboratory maintained by the Japanese in Palau for 10 years; (iii) the laboratories of the University of Hawaii; and (iv) the Carnegie Laboratory that operated for many years at Dry Tortugas and in nearby areas (activities in these areas have now been taken over by the University of Miami in Florida and the Lerner Laboratory at Bimini in the Bahamas). Institutions such as the Bishop Museum of Honolulu have supported many expeditions studying reefs in various parts of the Pacific, and the Pacific Science Board has sponsored many special atoll studies.

Studies of organic productivity, mentioned in connection with reef growth, have led to interesting conclusions about reef builders. Sargent and Austin (*20*) found the rate of productivity to be higher on areas of the reef than in the surrounding waters of the open sea, and concluded that reefs are self-maintaining structures. The Odums discovered that the average coral colony contained three times as much plant as animal tissue, most of the plant material being filamentous green algae in the coral skeleton. They concluded that the reef they studied represented a true ecological climax or open steady-state system (*21*). Hedgpeth expressed skepticism, suggesting that the experiments be repeated several times at different seasons to test some of the assumptions on which measurements were made (*23*).

Among many other biological problems directly connected with reef builders are those involving the production of skeletal calcium carbonate by the corals with the aid of symbiotic algae (zooxanthellae) (*24*).

Reef Blocks

On the surface of many reef flats, blocks of reef rock occur near the seaward margin. They range in size from coral boulders a foot or more across to massive blocks 20 or 30 feet long. The largest block noted during the Marshall Islands investigations was estimated at 200 tons. The block shown in Fig. 9 was estimated at 150 tons. Some earlier workers interpreted large reef blocks as outliers or remnants of former reefs or islands. Indeed, it is difficult to determine the origin of some large blocks because the actual contact with the reef

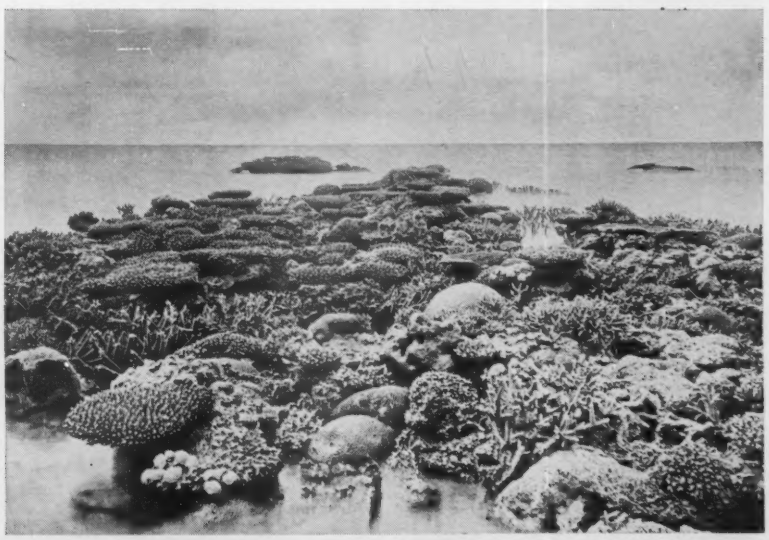

Fig. 4. Rich growth of corals exposed at low tide on Crescent Reef, Great Barrier, Australia. [W. Saville Kent, courtesy W. H. Allen and Co., Ltd.]

surface may be obscured by solution pits or overgrown by encrusting organisms. Some of the largest blocks may be remnants of an older reef, but there is now general agreement that most reef blocks are plucked from the reef edge or from the reef flat by storm waves.

The mechanics involved in moving the largest blocks are hard to understand, but the winds and waves that accompany hurricanes, typhoons, and tsunamis could move enormous masses if they were to strike an overhanging reef edge partially exposed at low tide (*25*). On 14 September 1953 there was a severe earthquake in Fiji. According to reports, the barrier reef on the eastern side of Suva harbor was raised about one foot, and large blocks of rock were thrown upon the reef by the tidal wave that followed the quake (*26*). In some areas reef blocks seem to follow a definite pattern, but the reasons for this are not clearly understood (*27*), and additional surveys would be welcome.

Landslides

In considering problems connected with the surfaces of reefs, the slopes below the sea, which control the outline of the reef at the surface, raise some interesting questions. Atolls tend to be circular, but many of the larger ones depart widely from this plan. They may show broad bights that are concave relative to the sea. Such indentations in the reef margin are well developed at Bikini Atoll, and submarine surveys there show that they continue to great depths. Fairbridge has suggested (*28*) that these are landslide scars, but those who charted the atoll (*27*) believe it more likely that the spurs and intervening bights reflect the original irregular shape of the flat-topped seamount on which the atoll was built. Drilling has shown that much of the reef complex of Bikini is unconsolidated, but there is believed to be a marginal wall of consolidated rock that would prevent large-scale slides. This question may eventually be resolved by additional drilling to more firmly establish the existence of the postulated marginal wall.

Fig. 5. Measuring depth in the surge channel through the algal ridge of the Bikini reef. [Fritz Goro, *Life*]

Passes

Most atoll and barrier reefs are broken by passes, some deep, others shallow. These have not received as much study as the more accessible reefs that border them, but enough has been done on passes through atolls to indicate that they probably record important steps in the Pleistocene history of reef building.

Each of the several large atolls studied in the northern Marshall Islands is cut by a single deep pass that is approximately as deep as the deeper parts of the lagoon behind it. Shallower passes through the reef are only as deep as the terrace that is well developed in the lagoon and on the seaward side of the reef. The deeper parts of the lagoon floor and the deep passes are thought to have been developed during the Pleistocene when, periodically, sea level stood several hundred feet lower than it does now. During the warmer interglacial stages of the Pleistocene, reefs developed on the prepared surface, growing upward more rapidly around the margins than elsewhere. This reef is thought to have flourished over the wide area now covered by the shallow terraces inside and outside the lagoon. The present reef is thought to have grown up during the postglacial rise of sea level, the shallow passes representing areas where for various reasons, possibly largely ecologic, the new reef did not flourish. This explanation, involving ideas suggested by Daly (*29*) and Kuenen (*30*), was given strong support by the detailed surveys of lagoons and passes made in the Marshall Islands (*27*). Its soundness should be tested by similar detailed surveys in other areas.

The lagoons of barrier reefs and the passes that connect them with the open sea are much less well known than comparable structures of atolls. The depths of some passes through barrier reefs exceed 100 fathoms. This is a promising field for future studies.

Beach Rock

Hard layers of calcareous sandstone and conglomerate occur on parts of many beaches behind fringing and offshore reefs. The layers, in most places, dip toward the sea or lagoon at angles of 8 to 10 degrees. The rock is especially well indurated on exposed surfaces, becoming more crumbly below. Beach rock is characteristically an intertidal deposit and, at best, the layers are but a few feet thick. Drilling on atoll islands shows that the layers are almost invariably present at intertidal levels (*31*). The beach-rock layers are wave-resistant and on many reef islands form the nearest approach to a persistent layer of hard rock.

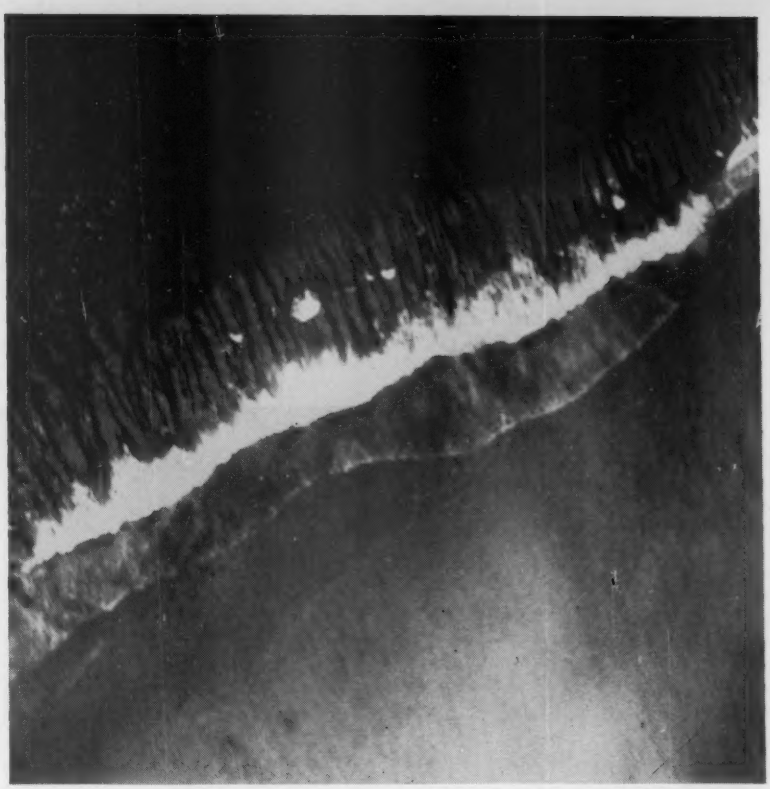

Fig. 6. Buttresses and grooves of the toothed edge of a windward reef, Bikini Atoll. The buttresses rise from a submarine terrace about 20 feet below the surface. [R. Dana Russell, air photograph from about 500 feet]

The process of cementation, in many areas, seems definitely to be occurring at the present time. In the Marshall Islands, for example, a piece of a Japanese glass fishing float was discovered by J. I. Tracey firmly cemented in beach rock (*27*). Many explanations for the formation of beach rock have been suggested. They involve evaporation of interstitial water and cementation by certain types of algae, by bacteria, and so on, but none is satisfactory as a general explanation. Emery and Cox (*32*) thought that detailed mapping of the occurrences might show significant relationships to the abundance and composition of ground water or to other factors of shore environment. They mapped widely scattered occurrences in Hawaii but were unable to give a satisfactory explanation. Richard Russell and his associates have recently completed an extended investigation of occurrences in the Caribbean area, with results as inconclusive as those of Emery and Cox in Hawaii (*33*).

Intertidal Erosion

The layers of beach rock that occur on many of the beaches behind reefs are subject to chemical erosion. Contiguous pits and basins are developed on exposed bedding surfaces, being especially numerous in the seaward half of the beach-rock belt. They are highly irregular, being often separated from each other only by knife-edge ridges. These depressions obviously are formed by solution, as are the deep nips that are invariably present on all limestone shores in the tropics at about high-tide level. This type of solution is limited to intertidal levels where marked diurnal changes take place, yet the process is difficult to understand because normal surface sea water is known to be super-

saturated with calcium carbonate. Revelle and Emery have suggested a hypothesis involving slow complexing or slow hydration and dehydration (*34*).

All reef investigators agree that some solution takes place at intertidal levels in reef areas, but since the process is not well understood, there is considerable disagreement as to its effectiveness. Revelle and Emery stated that the very existence of the broad and dead reef flat just below low-tide level indicated the efficacy of such solution, and they pointed out that it is as effective in sheltered lagoons as on exposed shores.

Much evidence indicating widespread reef planation—by solution, or waves, or a combination of the two—has been reported from the Pacific islands. For example; on the reef flats of Okinawa, MacNeil (*35*) found blocks of an older limestone (late Tertiary or early Pleistocene), weighing many tons, perched on pedestals of reef limestone 5 to 6 feet high at appreciable distances from the shore. The limestone blocks, broken from shore cliffs, appeared to have crept, slid, or rolled over underlying clays until they came to rest on a reef flat that stood 5 to 6 feet higher than it does now. Since that time they have been isolated by erosion that has planed 5 to 6 feet from the rest of the reef flat.

Recently, Norman Newell has questioned interpretations such as those given above. His investigations in the western Atlantic led him to believe that sea level is now at its highest position since the close of the Pleistocene and that intertidal erosion at this level has been negligible. He suggested that the elevated terraces in the Pacific may be of Pleistocene age (*36*). His conclusions involve a number of assumptions, and it can hardly be said that they invalidate the evidence for rapid intertidal erosion in the Pacific. Additional determinations of ages obtained from radiocarbon and other measurements from widely scattered areas may eventually resolve some of the differences of interpretation.

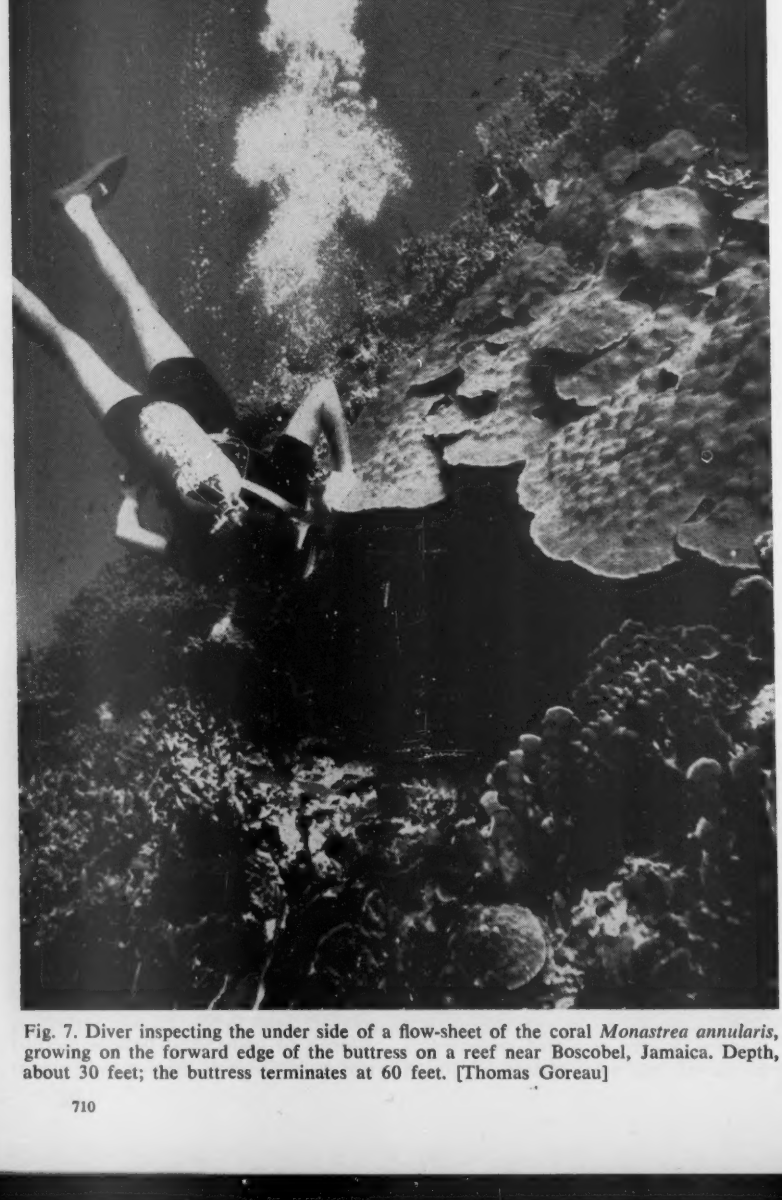

Fig. 7. Diver inspecting the under side of a flow-sheet of the coral *Monastrea annularis*, growing on the forward edge of the buttress on a reef near Boscobel, Jamaica. Depth, about 30 feet; the buttress terminates at 60 feet. [Thomas Goreau]

Origin of Reef Islands

The small low islands of sand and coarser debris that are found on many reefs, particularly on atolls, may be related to the postulated recent negative shift in the strand line of about 6 feet. Such a eustatic shift would stimulate erosion of any reefs that had grown to a higher level, resulting in masses of reef debris above the new (lower) sea level. Wave action is now shifting these masses slowly across the reef flat, and many are being reduced in size by wave activity. Evidence for this is seen in lines of truncated beach rock beyond the limits of the existing islands.

The Reef Complex

In 1950 Henson suggested the term *reef complex* for the aggregate of reef limestones and calcareous rocks associated with them (*37*). It is a useful term that includes the surface reefs, all outer reef structures, and the deposits that underlie the flat and the lagoon. The sediments making up the complex may be several thousand feet thick, with bulk ten times that of the controlling reef frame.

Charles Darwin was the first to think seriously about the thickness of reefs. His brilliant deductive theorizing on the nature of reef building was done before he had had an opportunity to see

a true reef. He was, however, familiar with the effects of elevation of the land and with denudation and the deposition of sediment. Mentally substituting subsidence for elevation, and coral growth in shallow water for sediment deposition, he reasoned that the three main types of reef—the fringing reef along the shore, the barrier separated from the shore by a lagoon, and the atoll without a central island—might be genetically related and controlled by slow subsidence. Thus, with upward and outward growth on a sinking island, a fringing reef could become a barrier, and the barrier, in turn, an atoll. He recognized, however, that an atoll could be developed directly from a shallow-water bank without passing through the intermediate barrier stage (*38*).

It is difficult to generalize on the relative importance of vertical as compared with horizontal growth. In the Pacific, where atolls abound, it appears that many have grown upward on truncated platforms without ever being fringing reefs or barriers. Vertical growth in some areas amounts to several thousands of feet. If the submarine buttresses that fringe many atolls are growth forms, they are growing laterally as well as vertically, and in turn, the marginal zone of the surface reef is growing laterally over the buttress area.

Charles Darwin was the first of several students of coral formations to refer to them picturesquely as monuments or tombstones over subsiding land. W. M. Davis, who saw reefs only as physiographic features, referred to the low-lying atolls as "inscrutable." The core drill established the aptness of Darwin's simile and the ineptness of Davis's adjective. Along with its cores and cuttings, however, the drill brought up problems not envisaged by either Darwin or Davis. Some of these still await a satisfactory solution.

The drill holes put down by the British on Funafuti Atoll in the Ellice Islands penetrated 1114 feet of Quaternary reef limestone, and below about 750 feet the rock was heavily dolomitized (*39*). The hole drilled by the Japanese on Kita-daito-shima ended in Miocene ["Oligocene"] beds at 1416 feet, the upper levels being dolomitized (*40*). The deepest hole on Bikini (Fig. 10) went 2556 feet into Miocene, with no trace of dolomite. On Eniwetok the drills went beyond 4000 feet to a basaltic foundation below upper Eocene limestones. One hole showed a little dolomite in the Eocene rocks, the other showed much more, also in the Eocene; there was a trace of dolomite in the Miocene rocks but none in the younger beds (*31*). S. O. Schlanger, of the U.S. Geological Survey (*41*), concluded that the island dolomites were formed in several ways. Others who are studying the Pacific island dolomites include Donald Graf of the Illinois Geological Survey, Julian Goldsmith of the University of Chicago, R. G. C. Bathurst of Liverpool, England, and a group from the Shell Development Company of Houston, headed by F. J. Lucia. When all these workers have reported, we shall, no doubt, know much more about the origin of dolomite. At the present time the problem of atoll dolomites is far from complete solution. The situation has not been simplified by the discovery of dolomite in Miocene ooze below 11,700 feet of water off the coast of Mexico in the preliminary Mohole drilling project.

Drilling of the "inscrutable atolls" has brought forth other interesting complications. The over-all history, as postulated by Darwin, has been one of submergence. In parts of the Pacific the submergence started at least as far back as the Eocene, and during the intervening 50 million years there have been several subintervals of considerable length when the tops of the atolls stood hundreds of feet above the sea. Eniwetok Atoll was a high island and bore a high-island fauna and flora—not once but several times. Drill samples from Eniwetok Atoll have yielded land shells of a type that lives on high islands rather than on atolls. There also are rich concentrations of spores and pollens that record the existence on the emerged atoll of a tropical deciduous forest (*42*). This paleontological evidence is supported by petrologic evidence. J. I. Tracey of the U.S. Geological Survey, who made a detailed petrologic study of the Bikini cores and cuttings, recognized a recrystallized (calcite) zone in the Miocene at a depth of more than 1000 feet, overlain by beds containing unaltered (aragonitic) shells and skeletons (*27*). As the upper layers of ocean waters are saturated with calcium carbonate, Tracey concluded that the leaching and recrystallization took place during a period of emergence. Schlanger, who studied the petrology of Eniwetok samples, found zones of leaching and recrystallization similar to those of Bikini. He has called them "solution unconformities" (*41*).

Reef Foundations

With the drilling of one reef (Eniwetok) to its volcanic foundation (Fig. 11) we have obtained a fairly good picture of how that particular reef was started, and we know the length of its life. Its base was laid in late Eocene time on the tops of truncated volcanoes two miles above the floor of the deep ocean. We are probably justified in extending the Eniwetok findings to other atolls in the Marshall Islands and, perhaps, to other atolls in the Pacific Basin proper. When, however, we consider atolls outside the basin we are less sure of our ground. When, for example, we cross the andesite line that separates the Pacific Basin from Melanesia, we enter a province where uplift, rather than subsidence, appears to have been the dominant geologic process in post-Tertiary times.

There are many barrier reefs and some atolls in Melanesia, and along with them are elevated Tertiary and younger reefs as much as 1000 feet above sea level. The Mbukatatanoa (Argo) reefs in eastern Fiji, for example,

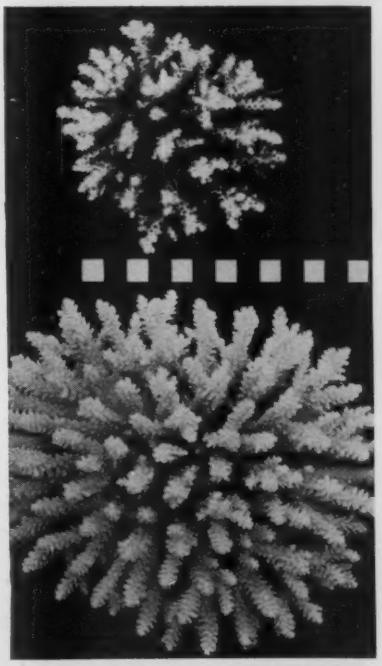

Fig. 8. Growth of coral planted on the Great Barrier Reef. This specimen (*Acropora quelchi*) increased 57 and 78 percent, respectively, on the greater and lesser diameters in a period of 187 days. White squares represent square centimeters. [T. A. Stephenson, courtesy Anne Stephenson and the British Museum (Natural History)]

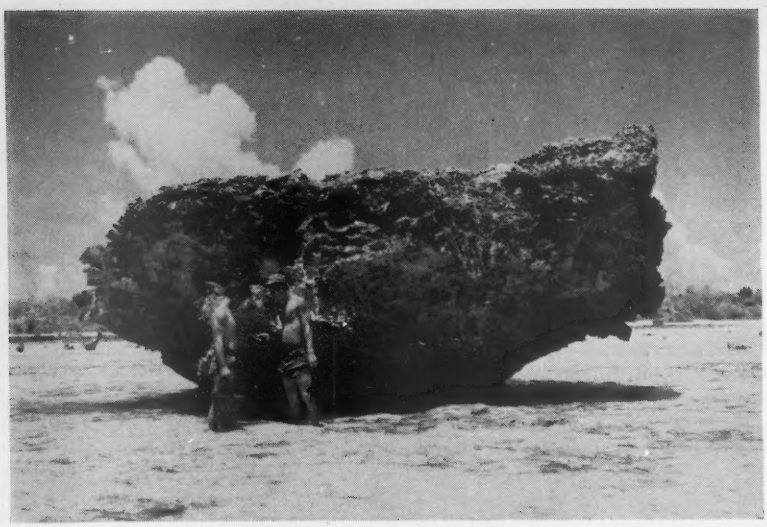

Fig. 9. Reef block on a reef off Enirik Island, Bikini Atoll. [J. I. Tracey, Jr., U.S. Geological Survey]

Fig. 10. Deep drilling on the lagoon shore of Bikini Island. [U.S. Navy]

form an atoll comparable in size to the larger atolls of the Pacific Basin, though somewhat more irregular in outline. The nature of the foundation upon which it grows and the thickness of the reef are not known, as neither drilling nor seismic investigations have ever been made there. The numerous barrier reefs in the same area have been examined in a few places. They lie off islands on which Tertiary and younger limestones are exposed above volcanics, but we have no definite idea of the nature of the foundation of the existing reefs or of the thickness of the structures.

Several submerged banks that may represent "drowned" reefs have been examined. One of these, Alexa Bank, in Fiji, measures 5 by 10 miles and has a raised rim and other features which suggest that it may once have been an atoll. A seismic survey indicated a depth of calcareous material of several thousand feet, comparable to that found at Bikini and Eniwetok atolls. The bank is assumed to have a volcanic foundation (*43*).

In the Indian Ocean, where atolls also occur, we know practically nothing about the nature of the reef foundations.

Links to Other Sciences

The building of reefs is primarily a biological process, but geological processes such as erosion and sedimentation enter as soon as the first reef organism is damaged by wave attack. Thereafter, reef building is a combination of organic and inorganic growth. Ultimately the effects spread to many other scientific fields.

Oceanography. Oceanography is concerned primarily with the chemistry of ocean waters and with their movements. In a broader sense it includes studies of bottom topography and many aspects of marine biology. On this latter basis, reef building is not only *linked* to oceanography—it is an integral part of it. I shall not attempt to discuss this broader relationship but shall cite a specific example in which the growth of reefs has, in an important way, directly affected strictly oceanographic processes.

The 50 atolls and small coral islands that form the Marshall and Gilbert island chain are spread across some 800 miles of ocean. The chain stands

athwart the Equatorial Current system, and small and insignificant as the reefs are at the surface, they cause large-scale eddies in the North Equatorial Current, the Equatorial Countercurrent, and, possibly, the South Equatorial Current (*44*). Acting with surprising effectiveness as a topographic barrier, the scattered atolls affect the circulation, the temperature, and the salinity of an enormous area of deep ocean.

Geomorphology. Existing reefs and reefs of the past are specialized land forms and have always had a strong appeal for the physiographer or geomorphologist. Recently emerged reefs, whether fringing, barrier, or atoll, retain their characteristic form for appreciable lengths of time, and a close study of the limestones of which they are composed will, in many instances, support the reef interpretation. Limestone masses of other types that have been elevated for long periods of time may, through the vagaries of atmospheric solution, assume a reeflike shape that may lead to the erroneous interpretation that they are reefs. All elevated limestone masses in the tropics tend eventually to assume a basin shape that strongly suggests that of an atoll, yet the mass may be composed of bedded limestones that accumulated below wave base. It is not safe, therefore, to assume, as some physiographers have done, that all basin-shaped islands were once atolls. Submerged banks and terraces may also represent old reefs, but none of these have been examined with sufficient thoroughness to establish their origin beyond question.

In the tropics all limestone masses that rise above the sea bear a nip or notch, whose center lies at about high-tide level. On most limestone islands there are remnants of what appears to be an older nip, whose center lies about 6 feet above present high-tide level. The prevalence of such an older nip in widely separated parts of the Pacific has led many workers to conclude that it records a time when the sea stood 6 feet higher than it does now. Attempts to date the beginning of the 6-foot fall by radiocarbon analyses have been, and are being, made. Cloud, after reviewing all types of evidence, suggested that the shift began 3000 (± 1500) years ago (*45*).

It should be pointed out that in the Pacific there is at least one area without an older 6-foot nip. Every one of the numerous limestone islands of Palau in the western Pacific shows a well-developed nip at existing high-tide level, but no trace of an older, elevated nip has been found. Wave erosion is known to be a factor in nip formation, but the controlling factor seems to be intertidal solution. In Palau, where rainfall is heavy and vegetation is dense—to yield necessary carbonic acid—it may be that solution proceeds faster than it does elsewhere. Conceivably, it may have proceeded so rapidly that all traces of an earlier nip have been destroyed.

Elevated and submerged reefs preserve evidence that points clearly to shifts in the strand line. In many instances this evidence seems to be tied to local elevation or submergence of the island or continental coast near which the features appear. Islands separated by several hundreds of miles may exhibit elevated strand-line features or buried zones of leached limestone that can be correlated, suggesting that the changes in land and sea were essentially uniform throughout an entire island group. Attempts have been made to extend correlations of this sort beyond single groups; indeed, such correlations have been stretched one-third of the way around the world—from the southwest Pacific through Hawaii to the eastern shores of North America (*46*). Those who support such interpretations postulate eustatic (world-wide) changes of sea level. The changes, however, imply a stability of the lands that is hard to accept because in many areas, including many island areas, there have been uplifts and submergences in fairly recent geologic time. In parts of the southwest Pacific, islands separated by only a few miles preserve old strand lines at different levels, and in other places the lines on opposite sides of a single island cannot be correlated, as the island has been tilted during elevation.

Attempts to correlate emerged and submerged strand lines over wide areas will doubtless continue, for they offer fascinating fields for speculation. As isotopic methods for dating limestones are improved it may be possible to establish some correlations more accurately and, perhaps, to come to some measure of agreement about eustatic shifts of sea level in late geologic time.

Petroleum geology. Structures having many of the characteristics of existing reefs have long been recognized in our older fossiliferous rocks, including those of the Paleozoic. Some geologists and biologists were loath to make direct comparisons between ancient and existing reefs because present-day reef builders did not exist in Paleozoic time. As early as 1911, however, Vaughan summarized available evidence and concluded that Paleozoic reefs were formed

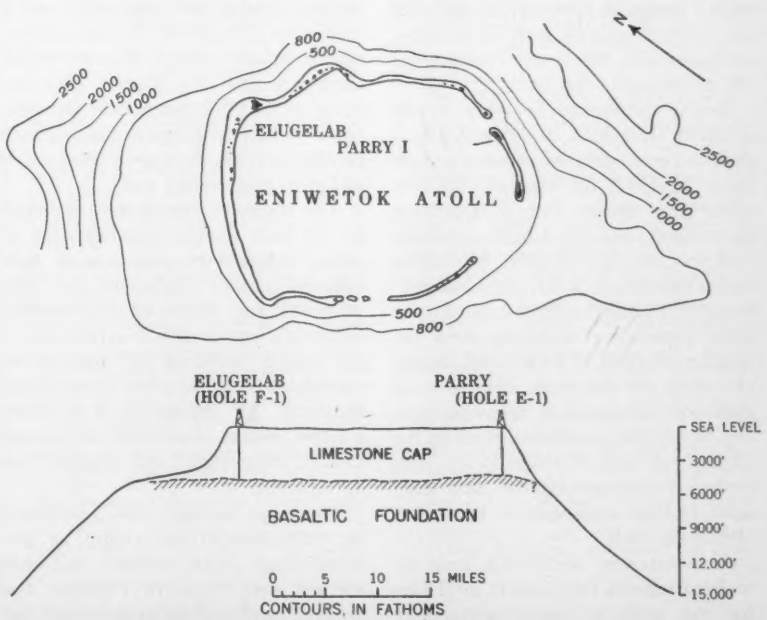

Fig. 11. Generalized chart and section of Eniwetok Atoll. [Contours from a chart prepared by K. O. Emery, 1954; after Ladd and Schlanger, 1960]

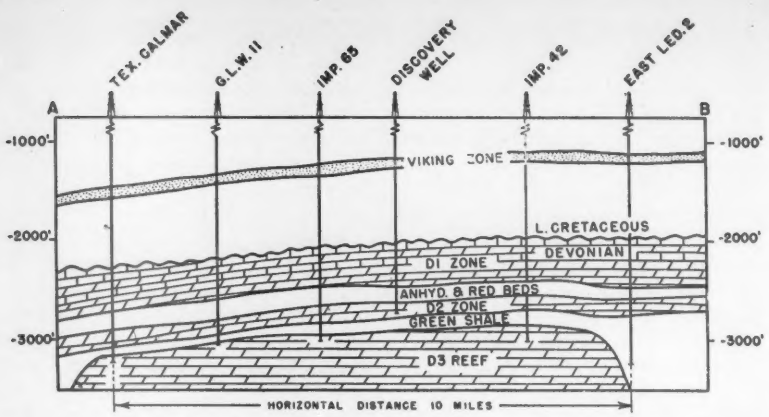

Fig. 12. Northeast-southwest section across the Leduc field. The vertical scale is exaggerated 20 times. [After Waring and Layer, 1950]

under conditions (depth, temperature, water circulation, type of bottom, composition, and specific gravity of oceanic waters) essentially similar to those of today (*47*). This interpretation took on great practical significance when rich deposits of oil were found by drilling ancient reefs.

As early as 1927 it was recognized that the Permian Capitan limestone of west Texas and southeast New Mexico had many of the characteristics of a reef (*48*), and in 1929 it was so described (*49*). This interpretation has since been documented by intensive studies (*50*). This ancient reef, which became a leading producer in the "Reef fields," compares favorably in size with the largest of existing reefs, as it is several miles wide, hundreds of miles long, and thousands of feet thick.

Similar discoveries in other widely scattered areas have demonstrated that ancient reefs form excellent reservoir rocks. In 1947, for example, the first wells were drilled into a Devonian dolomitized reef in Alberta, Canada. This became the highly productive Leduc field (Fig. 12) (*51*). With the help of the drill, geologists have learned more about ancient reef builders, about the regional relations of buried reef masses, and about the diagenetic changes (consolidation, cementation, dolomitization, and so on) that have taken place in the original reef rock. Needless to say, both geologists and geochemists have been aided in their investigations by studies of existing reefs.

Sedimentation. Reefs and their associated lagoons form nearly ideal sites for the study of many sedimentary processes. The lagoon of an atoll may be regarded as a large but fairly well controlled laboratory specializing in locally derived calcareous sediments. No foreign material enters the circuit except for minute pelagic organisms that come in over the windward reef, accompanied, on rare occasions, by pieces of pumice that have floated in from an up-wind volcano. The encircling reef effectively controls the waves and swells of the open sea, though a typhoon or hurricane may, on occasion, interrupt the established routine. Most reef lagoons lie in the trade-wind belt, and for nine months each year the winds blow fairly steadily from one direction. This may lead to the establishment of a primary circulation (overturning wind-driven circulation) and a secondary circulation (rotary circulation composed of two counter-rotating compartments) (*52*). Waters from the open sea feed this system over the windward reefs, and a comparable amount of water escapes through leeward passes and over the leeward reef.

The absence of terrigenous sediment on an atoll reduces the operation of many sedimentary processes to their simplest terms. There are no clay minerals, and much of the clay-size carbonate, apparently, is carried out of the lagoon. Most of the material accumulated in the lagoon is coarse clastic sediment. All deposition is in fairly shallow waters, and definite patterns can be recognized and mapped (see *27* and *53*).

Structural geology and geophysics. As mentioned in the section on geomorphology, both elevated and submerged reefs preserve evidence that points clearly to shifts in the strand line. In areas where the shift appears to have been regional, the reef evidence may give valuable support to theories involving major earth structures. In the western Pacific, for example, beyond the andesite line that separates the Pacific Basin proper from the continental area, many of the numerous islands are arranged in arcs that are convex with respect to the basin. Most of these arcs have deep trenches along their convex fronts, and there is much evidence from the study of seismology, volcanology, and earth gravity to indicate that these are active areas of orogenic deformation. There are considerable differences of opinion as to how the forces are acting and about the timing of major events, but there is agreement on certain aspects, and reef studies have contributed to the over-all study.

In the Pacific Basin there are scattered surface atolls and submerged flat-topped seamounts (guyots), both of which indicate submergence. The guyots now lie several thousand feet below the sea surface, yet dredging on them has yielded shallow-water organisms as old as Middle Cretaceous (*54*).

Biogeography. As already noted, existing reefs are the homes of many sorts of plant and animal communities. No other environment in the sea supports such a variety and abundance of life. Scattered as they are over an area of more than 50 million square miles, reefs offer unrivaled opportunities for the study of geographic distribution and the relations of organisms to each other. The faunas and floras of ancient reefs are as yet comparatively little known, but the field holds much promise, and studies of older reefs should add greatly to our understanding of present geographic patterns.

As an example, I should like to cite a proposal for which definite plans are now being considered. The plan calls for the drilling and sampling of a deep hole on Midway Island in the Hawaiian Islands—a hole that would penetrate the sediments beneath the existing reef and reach the basaltic foundation. The importance of Midway becomes clear if we briefly review the known and the assumed history of the Hawaiian Islands.

The surface geology of the Hawaiian Islands—located in the center of the world's largest ocean—has been worked out in considerable detail (*55*). The chain stretches for 1600 miles from northwest to southeast. The exposed rocks are almost entirely volcanic, the oldest probably being late Tertiary in

age. Geologists have long favored the view that the northwest islands are the oldest and that volcanism progressed southeastward to the island of Hawaii, where such activity still persists. It is thought that the outpouring of lavas to build islands from the floor of the deep sea depressed the crust, causing slow submergence which, like the volcanism, progressed from northwest to southeast. Islands, such as Midway, on the northwest, are now coral reefs, and a considerable thickness of calcareous sediments probably lies beneath them. If several thousand feet of fossiliferous sediments underlie Midway, a drill hole might disclose a history dating back to the Cretaceous or even earlier. Before attempting the expensive process of drilling it would be well to check the thickness of the sedimentary cap with a seismic refraction survey. Plans for such a survey are being formulated, and it is hoped that drilling will follow.

If such a drill hole can demonstrate and document an appreciably longer geological history for Hawaii than is indicated by its youthful surface rocks, it would offer a reasonable solution for one long-standing biogeographical problem and might throw considerable light on another.

1) If it can be shown that the Hawaiian Islands date back as far as the Cretaceous, and if it is assumed that they were built up slowly—flow by flow—as they are being enlarged today, it will appear that there may have been some land in existence during all post-Cretaceous time. In that case, the land plants and the land invertebrates (land shells), which show a high percentage of endemism and have long been recognized as ancient stocks, would always have had a home of sorts. There would be no conflict between biological and geological evidence.

2) If the marine invertebrates obtained from such a drill hole are comparable in diversity and abundance with the faunas obtained from similar drill holes in the Marshall Islands, this would lend support to the suggestion that many elements of the Indo-Pacific fauna (now widely thought to have migrated *from* Indonesia) actually originated in the mid-Pacific and migrated, with the help of favorable winds and currents, *toward* Indonesia (*56*, *57*).

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Public Education for Science and Technology

What is the role that the universities should play in dispelling popular myths about science?

A. Hunter Dupree

The mid-20th century may be called an age of science not because all men are scientists or because all men understand science but rather because the forces unleashed by science are incomparably powerful. The lack of understanding between those who can call themselves scientists and those who only see the effects of science has become a dangerous schism even in the English-speaking world, which conducts a more than proportional share of scientific research. Ever since the advent of universal literacy and free public schools, it has seemed reasonable to expect that the educational system itself should provide every citizen with some understanding of science. Yet the present scene easily confounds such an easy belief. The school system has left many citizens sadly confused concerning the nature and significance of science. "Public education in science" is used here as distinct from the efforts of the school system proper and as supplementary to them. Hence, public education must take into account the great and growing gap between the accomplishments of science and the understanding of their significance by citizens at large.

The people of the English-speaking world of the 19th century had fewer doubts about the desirability or the possibility of public education in science. Their enthusiasm was a part of their belief in universal education, and their goal included science as a part of respectable culture. The lyceum and the workingman's institute not only included science but gloried in it. Outstanding scientists such as Sir Charles Lyell considered public lecturing a natural part of their proper role. In America, Benjamin Silliman and Louis Agassiz looked upon the lecture podium as a place of opportunity equal to the laboratory and the classroom. And T. H. Huxley, one of the greatest molders of scientific opinion in history, worked out many of his most effective essays not in learned journals but before audiences of workingmen. Indeed, Huxley's "On a piece of chalk" and other lay sermons are still dominant models for the popularization of science.

The audiences of the middle 19th century responded with equal enthusiasm. The crowd in Boston which broke a plate-glass window at the Old Corner Bookstore trying to get tickets for a Lowell Institute lecture is not easily duplicated in 20th-century America. And the audiences flocked in to hear the straight science of the day. Many a lyceum lecture was a direct transplantation of a section of a college textbook. Amos Eaton, the great impresario of science in New York State in the 1820's and 1830's, gave chemistry demonstrations to the New York legislature. Both scientist and audience shared a belief that the common man could understand science, that the professional had a duty to explain science to the public, and that a massive uplift in society would result from their joint activities.

Twentieth-Century Phenomena

To understand the predicament of the university in the mid-20th century, one must examine what happened to the 19th-century faith in public education in science. To say that a scientific revolution has taken place is too trite. Instead, let us point to three obvious and major phenomena which have accompanied that revolution. In the first place, science has become complex far beyond the comprehension of any one mind, professional or lay. Specialization has made possible the esoteric development of hundreds of lines of thought and research, to the point where acquiring an initiate's knowledge of any one of them is impossible for all but an infinitesimal proportion of the whole body of citizenry. The pessimism engendered by this complexity has led both the audience and scientists of the stature of Huxley and Agassiz largely to withdraw from the arena of public education.

In the second place, science has lost its place as a part of genteel culture and has emerged instead as the partner of technology. Until it was coupled with science, technology was largely a stabilizing factor in society, a brake upon change. When in the late 19th century it became coupled with science in a regular, continuous, and institutionalized partnership, technology reversed its historic role and became the major disruptive force as well as a major creative force in every Western society. People sensed rather than understood that science had something to do with this outburst of technological power, and in general leaped to a disastrous assumption which confuses the public today—the belief that science and technology are identical. This confusion led much public education in science, from the 1920's onward, to take the form of pointing in wonder at the end products of technology. If you would teach a student about science, show him a motorcar. The familiar will eventually lead to the unfamiliar, and the principles of mechanics, of combustion, and of expansion of gases are all accessible by this route in a miscellaneous array. Also, unfortunately, many citizens have drawn from this method of education the impression that high among the ranks of American scientists stands Henry Ford.

In the third place, a combination of the first two trends has produced a situation in which the guild of qualified scientists is completely unable to man all the posts in society which require an understanding of science. Each major application of science to technology brings large segments of society into a working relation with the scientific establishment. To give just one example, radar in 1937 was almost exclusively in the hands of guild scientists in research laboratories. Yet by early 1945, when the Fifth Fleet concentrated at Ulithi

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Atoll, half a world away from M.I.T., the forest of antennas implied that thousands of men of all ranks and rates had been forced to acquire some understanding of the principles of radar. This thousandfold increase was not accomplished by putting Ph.D.'s on every mine sweeper and patrol plane, but rather by forced and fragmentary education in science of large occupational groups which theretofore had been largely innocent of electronics. Since World War II the impact of science on new groups has continued to increase. Labor leaders, business executives, and stockbrokers are increasingly enmeshed. And most of all, the statesmen and politicians and civil servants find themselves deep in questions of science polity, regardless of their backgrounds. And as a complement to this involvement, the scientists find their affairs less and less the subject of guild determination and more and more in the hands of those outside the guild who are concerned with larger questions of policy.

These three trends have paradoxical effects. They remove the common man from any possibility of understanding science at its highest level, while at the same time they enmesh more common men directly in the affairs of science. They make the common man feel science all around him with the flood of technological end products, thereby obscuring the distinctive role that science plays independent of its technological applications. Perhaps the only clear impression which emerges is the inadequacy of the 19th-century pattern of public education in science. The one approach that gives least promise of success is the 19th-century effort to make every man a scientist by giving him a lecture at a lyceum. Yet the pessimism here implied is matched by the heightened sense that civilization must not be allowed to fragment itself without a protest on the part of the universities. One way to get a more realistic appraisal of the problem facing us is to do away with the formidable task of providing public education for the common man and to break him down into distinct audiences created by the trends we have already mentioned.

The Cargo Cult

The habit of approaching science by way of technological end products produces an audience held in thrall by what we may call, by loose analogy from anthropology, a cargo cult. When in World War II the natives of Melanesia beheld the terrible and wonderful end products of Western technology coming ashore as cargo from the fleets of ships, they could see neither the industrial system nor the pattern of ideas which produced these unimagined riches. Their reaction, however, was based both on close observation and on cause-and-effect reasoning. The white men who possessed the cargo engaged in mysterious paper-passing rituals and erected feathery metal monuments to their gods, with whom those who possessed the secret of the cargo could communicate, thus bringing more ships and more cargo. By grafting these observations onto stories of a messiah, as half-understood from missionaries, and onto assorted native myths, the islanders were soon seized with the millennial ecstasy of the cargo cult. They stopped work, neglected their tribal customs, and built bamboo antennas on their huts in order to communicate with the new messiah who would bring the cargo to them!

Without pressing the analogy too far, one can nevertheless assert that a cargo cult exists in American society itself. Many of the symbols of science in the public mind are no more functional parts of the scientific enterprise than are the bamboo antennas of the Melanesians. Scientists appear as white-coated witch doctors manipulating the mysteries of an esoteric cult. The public, failing to understand science, nevertheless worships it as a messiah while fearing its diabolical power. Technological marvels, called science by the cults, add to their undeniable power by corroding the fabric of society with the false hope of an immediate millennium.

The universities, which are among the few institutions in American society possessing the resources to describe the whole process from basic science to technological end product, have a positive duty to discourage the cargo cults. Any program of public education to which they subscribe must make clear the difference between science and the artifacts of technology. And the universities must not delude themselves into thinking that by taking no action they can merely leave the citizenry innocent of science. The cargo cults are already loose among the people, battening on the stereotypes fed by mass communication media. The longer the inaction lasts, the firmer will be the hold of the cargo cults and the harder it will be to dispel the mysteries surrounding science.

Two Audiences

In this framework, the university can begin to identify one large audience to whom it has something to say about science. A large group of people of all levels of education and of all social classes emerge from school and college knowing so little science that they are ripe for the cargo cults. The universities cannot dream of recruiting scientists from this group, nor can they dream of making every voter his own scientist by serving freshman courses to the public. What they can perhaps do is give this group a sense of how science deals with problems. If each person can be led to think about one problem as the scientist thinks about it, he will be much less likely to make the confusion of ends and means which lies at the base of the cargo cult. Since much scientific thinking does go on in a university, the university is a proper and even necessary agency for telling the public how a scientist uses his mind, and for showing that in any given situation scientific reasoning is not mystery but its opposite.

Too much dissatisfaction with the teaching of science at all levels exists to make the design of a program of public education in science for this first and largest audience an easy task. As much as a quarter of a century ago C. P. Snow had a scientist in one of his novels rail against the logical method of teaching science and regret his own miseducation.

Others have seen the inhuman and lifeless form that is left when the path of science becomes inexorable logic. Their remedy is usually to present science as a form of history. Recount, they say, the wayward course that science has actually taken in order to grasp the life of the enterprise. Then one may fathom the unpredictability and excitement of research. The universities should consider carefully whether this is a real way out.

Even if the great mass of people who misunderstand the nature of science could be brought to a state of appreciation, however, the universities would still feel the need for a program of public education. For another large and growing audience has a different and even more pressing problem. The army of technicians, administrators, military men, and philosophers who have recently come within the umbra of science are sufficiently versed in some form of science to avoid the grosser obscurities of the cargo cults. But they desperately

need to understand science as a social and institutional expression of a tradition of which they themselves are not a part. The social relations of science are no longer merely internal, within a closed guild. They are a fundamental part of the policy of a nation and of the international community. The audience of people within the umbra of science consider science not so much a system of ideas about nature as a social activity among men. Many in this audience are in command of sophisticated bodies of scientific information. Many of them, however, have only outworn slogans with which to analyze the changing role of science in society. Can any public servant do his job today without some appreciation of the changed relation of the government and science? Can any business executive make adequate decisions without some appreciation of the role of the industrial research laboratory? Can any university official operate today on the assumption that he has no scientific connections with the government and industry? Is any military or diplomatic problem understandable apart from the scientific problem that is involved? These questions involve political, social, and economic issues in society as a whole. And on their resolution could depend survival itself.

The ability of the rich and varied empires of science to mount a program of public education may be open to question, but a glance at any American university's resources for studying science as social activity reveals only appalling weakness. Despite the hundreds of scientists on its faculty, a university can usually count the scholars working on the social relations of science on the fingers of one, or at most two, hands. And even these scholars are scattered through several departments of the humanities and social sciences and are out of touch with one another, distracted by other interests and demanding duties. Would not a public education program in science as a social activity only reveal to the world the scandalous neglect of this subject by the universities? Possibly so. But there is a surprising amount of literature, written in at least passably plain English, stacking up in this area, which might provide a sufficient basis for discussion. One cannot conceive of didactic teaching on the basis of present knowledge. But a body of information does exist, at least enough for interested people to ponder. It is the importance of the questions, not the availability of answers, that bids people attend. If this were not so, how could international affairs and the cold war have any place in public education?

In summary, the trends in 20th-century science sketched here call for the universities to mount not one but at least two programs in public education in science. The first must be designed for an audience that does not know what a scientist does or how he thinks or solves a problem. The second must be for an audience already in touch with science and challenged by that very fact to understand it as a social activity. In neither case does the university possess the manpower to man the programs directly. Rather, it must decide whether these programs can be carried out indirectly, through techniques of public education developed in other fields. Above all, however, the universities must not, in their preoccupation with the difficulties of doing anything in public education, forget the price they will pay if they do nothing. Misunderstanding science and its role in civilization levies a toll on all mankind.

Science and the News

As Interpreter of Soviet Moves, Khrushchev Remains the Best Kremlinologist

For those whose job it is to explain the Khrushchev Effect, the last 2 weeks have been busy ones, indeed.

Without so much as stumbling, Khrushchev has ordered Soviet test resumption; demanded a settlement of the "German problem"; scoffed at the neutrals; caused the United States to resume nuclear testing; and rejected an appeal for an atmospheric test ban.

At the same time, the French agreed to U.S. nuclear arms training for their troops; Congress acted favorably on a permanent U.S. disarmament agency; a badly mauled foreign-aid bill was authorized; and the Geneva test-ban talks were indefinitely postponed after 340 sessions.

Meanwhile, intrepid Soviet and U.S. scientists met in the sylvan tranquillity of Vermont to discuss mutual interests; Eastern and Western scientific confreres met in Vienna to exchange data on fusion research; U.S. disarmament negotiator John J. McCloy met with Valerian A. Zorin to plan a general disarmament conference; and the nettlesome Jack Parr upstaged two colonels, a lieutenant colonel, a major, a captain, two lieutenants, and a platoon of enlisted men in Berlin.

At best, attempts from beyond Red Square to explain all the actions and reactions that result from the Khrushchev Effect are conjectural. Clearly, the best Kremlinologist is Nikita S. Khrushchev. In recent weeks he has repeatedly spelled out his plot. He is authoring an anatomy of terror. And, for the moment, at least, he seems to be succeeding.

Khrushchev wants two Germanys and an independent Berlin. Although he is willing to subject his demands to a second Kennedy-Khrushchev confrontation—and there could very well be an East-West summit meeting soon—most observers agree that Khrushchev would remain intractable in his demands. In this, Khrushchev mimics the World War II aphorism that there is a right way, a wrong way, and the Army way of doing things. To settle the Berlin crisis, there is only the Khrushchev way, in Khrushchev's view.

The Soviet resumption of nuclear testing is inextricably linked to the

Berlin crisis, though it has its military needs, too. Undoubtedly, there are other concomitant underlying and overriding Soviet reasons for resumption. It is in the nature of this conspiratorial beast that cause and effect is a well-spun web responsive, always, to the spider in the middle no matter where upon the web the fly is enticed to light.

Bullying

Politically, Khrushchev is using nuclear testing to bully the Western alliance and the neutralists. And he has made no bones about dealing in "atomic blackmail." He is threatening thermonuclear war hoping to cow the West into accommodating him on Berlin and Germany, and to cow the neutralists into pressuring the West for this accommodation.

The neutralist leaders, at Belgrade, were more interested in condemning the only colonialism they know than in openly castigating the devisers of a new colonialism. Two neutralist delegations were scheduled to present an appeal for peace to President Kennedy. Prime Minister Nehru of India was assigned a similar task toward the Soviets. But Nehru, who faces grave internal challenges at home and wants more Soviet aid, was singularly ineffective in his suasion.

The sum effect seems to be that the neutralists are the first victims of this newest phase of the Cold War. Khrushchev showed his contempt for their influence as a third force. Even President Kennedy seemed irritated with the neutralists. He said, upon signing the foreign-aid bill, that it "should give great attention and consideration to those nations who have our view of the world crisis."

The neutralists' failure to speak out illustrates another point—the curious role of propaganda. After the first well-deserved pats on the back that the United States had shown great restraint and statesmanship in not being the first to resume nuclear testing—despite considerable pressures upon President Kennedy to do so—sober second thoughts suggest there is a half-life value to propaganda, which in this particular case equals that of the omega meson, the fleeting elementary particle whose discovery at the Lawrence Radiation Laboratory was reported on 1 September.

If Khrushchev holds a trump of terror it is the 100-megaton warhead he has talked about repeatedly. There is every reason to believe the Soviets will build such a weapon, if they have not already done so. Khrushchev told C. L. Sulzberger of the New York *Times*, "Let those who dream of new aggression know that we shall have a bomb equal in capacity to 100,000,000 tons of TNT, that we already have such a bomb and shall test the explosive device for it."

It is even conceivable that the Soviets will, in fact, detonate such a weapon at high altitude for the world to witness. Such a horrifying prospect is not without precedence or rationale. After all, this type of display was what many American scientists implored President Truman to do with the first atomic bomb to bring about Japanese capitulation.

Although U.S. officials have expressed no interest in a 100-megaton device as a military weapon, the Soviets could be mindful that big rocket boosters were once considered wasteful military devices but, happily, turned out to have overwhelming psychological meaning for space exploration and spectacularism.

In recent days, there have been suggestions that the United States go on to build a 1000-megaton device as a counter force. This type of thinking bears witness to Freeman Dyson's belief that the importance of new nuclear weapons is they are technically a symptom of further advance in nuclear technology and politically a symbol of military power.

U.S. Underground Tests

The knowledge that the fallout from a 100-megaton detonation would be severe does not seem to disturb Khrushchev. He rejected the Kennedy-Macmillan bid for an atmospheric test ban. This appeal had an error of omission—France was not included. And Khrushchev used this as part of his reasoning for rejecting the bid. He also condemned President Kennedy for ordering a resumption of underground U.S. testing before the 9 September deadline set for Khrushchev's reply to the atmospheric test ban.

It is doubtful, however, that Khrushchev would have agreed to the proposal in any event. There seem to be compelling reasons for the Soviet military to test nuclear weapons. The best guesses are the Soviets want an antimissile missile; more efficient and lighter warheads; and a trigger for the big bomb. Khrushchev argues that the Soviet Union has set off many fewer blasts than the United States, Britain, and France. "We have every reason, both from the viewpoint of morality and of ensuring our national interests," he argues therefore, "to claim an equal number of test explosions with the Western powers."

These and other Khrushchev statements had already dimmed the prospects that the Labor Day weekend proposal by Kennedy and Macmillan would be accepted, and this was very clear to the Western powers before the 9 September acceptance deadline. What is not totally clear to observers, however, is why President Kennedy ordered a resumption of U.S. testing when he did.

There had been considerable prior speculation that the President would defer such a decision at least until after 9 September and perhaps until 19 September when it is anticipated he will address the United Nations. (There is also the possibility that the impulsive Mr. K. might come to New York to table thump in his own defense.)

One report has it that upon hearing of the third Soviet test on 5 September the President decided he had had enough. "In view of the acts of the Soviet Government," the President said, "we must now take those steps which prudent men find essential. We have no other choice in fulfillment of the responsibilities of the United States Government to its own citizens and to the security of other free nations."

The President's decision fit the Administration's policy of convincing the Soviets that the United States will use its nuclear arms if the need arises and fit the nation's ancillary policy that its carefully made decisions are not to be interpreted as signs of weakness by enemy, ally, or unaligned.

The decision has been made and underground testing will resume shortly in Nevada. There is danger, however, that the Soviets will complete their many tests by 19 September—just as U.S. testing gets under way and the United Nations meets. At this point the Soviets could again announce a unilateral moratorium and the U.S., with its sensitivity to world opinion, could find itself in a political dilemma.

Although the first U.S. tests will be conducted underground, it seems only a matter of time before this nation, too, will resume atmospheric testing, even if limited. There are bound to be great pressures created, particularly by the

military and paramilitary scientists, to this end. After all, wars are not fought underground and there will be arguments that the antimissile missile must be tested in the atmosphere, if the nation is to be effectively protected.

Thus, fallout dangers will increase markedly, properly heightening worldwide fears and again raising the specter and voice of genetic doom.

According to Khrushchev, there is an out. In rejecting the proposal to ban atmospheric tests, he said, "It is possible to end nuclear tests . . . only on the basis of general and complete disarmament." This is a complete turnaround. It was the Soviets who originally insisted that nuclear testing be separated from general disarmament talks and the U.S. accommodated them in this. Whether the U.S. will again accommodate the Soviets remains to be seen. Hopefully, the channels for disarmament negotiation have not been closed. But there is little more than this to comfort an anxious world.—HOWARD SIMONS

While Howard Margolis is on vacation, his section will be written by guest reporters. Howard Simons, this week's guest, is on the staff of the Washington Post.

Wilderness Protection

The Senate last week approved a bill to strengthen existing regulations against the intrusion of civilization upon millions of acres of federally owned wilderness. The bill, which is yet to be considered by the House, is of vast and far-reaching significance for the preservation of some of the nation's most splendid and untouched woodlands and mountains.

In passing the bill, the Senate recognized the pleas of conservationists who have long argued that now is the time for increased protection, before increased demand for space, timber, and minerals inevitably brings pressure against the boundaries of these huge, unpopulated, and unexploited areas. Under the bill, some 6.7 million acres would be placed at once in a National Wilderness Preservation System. In addition, another 60 million would be reviewed, and of these, it is expected, some 35 million, probably all in the West, would qualify for eventual inclusion.

The demand for additional protection was heightened by a number of factors, all of which portend hazards for the preservation of these lands in their natural state.

One of the factors is the shrinkage of state, county, and municipal parklands, especially at the hands of road builders, who, following the line of least resistance in seeking rights-of-way, have found that citizens are more inclined to fight for their homes than for their parks. Another is the long-range, but growing interest in the commercial exploitation of wilderness resources. And still another is the boom in camping, which has resulted in what have been called camping slums in some of the more popular national parks.

Restrictions

The Senate bill contains severe restrictions on the use of lands in the Wilderness Preservation System and reflects the conservationists' disillusionment with compromises that have resulted in encroachments upon many supposedly protected areas. Development in the wilderness is not a reversible process, at least over the short run, and each loss to the bulldozer is regarded as irretrievable.

The bill would, in effect, "lock up" wilderness areas by barring road construction and prohibiting motor travel, including aircraft and motorboats. The only access would be on foot or horseback, thus eliminating the likelihood of great encampments of tents and trailers, and attendant refuse, which have disillusioned some conservationists about the wisdom of opening the outdoors to the American public. Without exceptions granted by the President, no construction or exploitation of resources would be permitted. As was pointed out by the bill's opponents during the Senate debate, it would not be easy to obtain such exceptions.

The lands proposed for inclusion in the Wilderness Preservation System are all federally owned and are under the jurisdiction of agencies of the Interior and Agriculture departments. Their preservation in a wilderness state has, with a few exceptions, been the policy of both departments, but the matter is at the discretion of the Secretaries, and trends disturbing to conservationists have become apparent over recent years. Among these has been a steady increase of commercial interest in the potential of these lands, increased prospecting, which is lawful, and, perhaps most alarming, the disclosure that a sizable number of oil leases were granted on Fish and Wildlife Service lands during the Eisenhower Administration while a moratorium supposedly was in effect.

A significant feature of the bill is that it would give the President, rather than the Interior and Agriculture secretaries, the authority to make exceptions to wilderness preservation. The change may appear to be a small one, but it is of great importance for the tactical problems that confront both the advocates and opponents of preservation. The departmental agencies that manage the lands, such as Interior's Park Service and Agriculture's Forest Service, are neither well publicized nor unsusceptible to congressional pressures. The White House, on the other hand, is strongly sympathetic to wilderness preservation, for the time being at least, and provides a well-illuminated arena for a great public row if the conservationists feel they are ill-treated.

The bill approved by the Senate also provides the President with authority to add federally held lands to the Wilderness Preservation System, unless there is an opposing resolution adopted by either house of Congress. Since it is generally easier to block than to achieve positive action on Capitol Hill, conservationists look upon the Senate bill as a route to great expansion of the wilderness system. In support of this optimism is the fact that "wilderness," like national defense and medical research, does not lend itself to easy opposition. Even the mining and timber interests which doggedly opposed Senate passage —Senator Humphrey declared that "the abuse from the vested interests has been unbelievable"—stressed that they are for wilderness preservation. They explained, however, that they opposed the bill because it created restrictions which they considered unnecessary in view of existing Interior and Agriculture department regulations.

The final vote was 78 to 8, with much of the expected conservative opposition failing to materialize. In part this was due to the fact that the wilderness concept not only is attractive to persons of all political persuasions, but also that it involves no expenditures, merely redesignation of existing federal holdings. In addition, while the long-range economic interests of mining and timber industries are clearly affected, the areas concerned are empty, and the opposition could call upon no constituency that would be aroused by the pros-

pect of the federal government blocking economic development.

The issue of economic effects was considerably befogged during the Senate hearings and debates by mining and timber interests which contended that the wilderness system would have a harmful effect on employment in the West. The fact, however, is that there is no lumbering at present on the lands involved, and only eight mining operations are under way, all of which would be permitted to continue. Cattlemen for a time showed some opposition to the bill, but their interest waned when it was stipulated that the relatively little grazing now permitted in wilderness areas would be allowed to continue.

With the rush under way to end the current session, the House is not expected to act on a similar bill this year. Its Committee on Interior and Insular Affairs, however, is considering hearings sometime before the start of the next session.—D.S.G.

Overhead Allowance Unchanged

A Senate-House conference last week voted against raising the 15 percent overhead allowance in research grants and contracts awarded to universities by the Department of Health, Education, and Welfare. The conference action settles the matter for the current session of Congress.

As in past years, the Senate Appropriations Committee recognized the pleas of university spokesmen and voted for 100-percent payment of overhead costs. However, the House Appropriations Committee has never been receptive to an upward revision of the allowance. A principal source of opposition has been Rep. John E. Fogarty, the Rhode Island Democrat who is chairman of the Appropriations subcommittee that passes on funds for HEW.

It is Fogarty's view that since the government provides 100 percent of the direct costs on HEW research grants and contracts, the recipients are not unfairly burdened by the requirement that they meet part of the indirect, or overhead, costs. Direct costs include salaries, equipment, and supplies, which are easily visible items in any project, while the indirect costs are in the less obvious, but still burdensome, categories of maintenance, depreciation, library services, and physical space in university buildings.

At hearings last April, Randall M. Whaley, vice president for graduate studies and research at Wayne State University, told Fogarty's committee that some of Wayne State's departments were declining HEW grants and contracts because of the limitation on overhead cost payments. The committee was also told that the average of overhead costs at 50 small institutions was 42 percent of project costs, while at 10 larger ones it was 34 percent. And it was pointed out that a formula suggested by the Bureau of the Budget provides for overhead allowances considerably higher than 15 percent.

Fogarty, however, feels that the limitation cannot be a serious drawback in view of what he regards as general receptivity among universities to accept research funds from HEW.

The Administration came out in favor of the government meeting full overhead costs, but it did not convey to the conferees any sense of great concern about the problem. Its budget request of $2 million for higher payments would provide an increase of less than 1 percent.

School Aid Maneuvering

Senate backers of the President's school aid program failed this week in an attempt to use fragments salvaged from the defeated Administration bill as a wedge for reopening the fight next year. Their efforts were directed at limiting renewal of aid to impacted areas to just 1 year, which would have assured the issue of federal aid a place on next year's congressional agenda.

The politically-popular impacted aid program, which the House renewed last week for 2 years, provides assistance for school districts whose enrollments are increased by federal activities. The ease with which it has been passed previously led the Administration to tie it into the omnibus education bill as a lure for votes, and when that bill met defeat, to propose that impacted aid should be restricted to 1 year to serve as a vehicle for renewing the fight next year. The need for such a vehicle was deemed especially important because of considerable sentiment, especially in the House, against reopening the school-aid battle in an election year. Despite a last-minute personal plea from President Kennedy, the Senate voted 45 to 40 for a 1-year renewal.

Announcements

A 5-year experimental program to determine the part cholesterol plays in heart disease will begin this fall in Boston, Baltimore, Chicago, Minneapolis, and Oakland (Calif.). The National Heart Institute will choose 250 males in each city to participate in 6- to 12-month pilot studies. The program is expected to involve as many as 400,000 Americans before its completion.

A technical review of the **nation's space-flight effort** will be presented from 9 to 15 October in New York. The meeting, sponsored by the American Rocket Society, will consist of sessions of technical papers outlining work in the rocket, missile, and space-flight fields; panel discussions on space vehicles, space missions, and the global aspects of space flight; an exhibition, open to the public; and evening programs (probably to be televised nationally) which will review the complete U.S. and U.S.S.R. space programs. (Roderick L. Hohl, American Rocket Society, 500 Fifth Ave., New York 36, N.Y.)

A list of 679 **paperbound science books**, recommended for high school students, college undergraduates, teachers, and the educated general public, is contained in the 5th annual edition of *An Inexpensive Science Library*. The new edition consists of a selected list of books recommended in former editions, older books overlooked in previous editions, and newer books available in the United States up to 31 July 1961. The catalog, published by the AAAS's Science Library Program administered under a grant from the National Science Foundation, also contains title and author indexes, names and addresses of publishers, and a list of dealers in paperbound books. (AAAS Publications, 1515 Massachusetts Ave., NW, Washington 5, D.C. $0.25)

An article on the **ecology of space flight**, translated from a recent issue of the U.S.S.R.'s *Physiology Journal*, complains that Western scientists have given little attention "to the interrelationships of the [astronaut's] basic nervous processes." Citing the results of U.S. isolation tests, the article concludes that the U.S. experiments suppress "social reflexes" and the astronaut's "awareness of danger" and fail to make

any fundamental contribution to the theory and practice of space medicine. (Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. Order No. 61-31491. $0.50)

Courses

The fifth advanced course in the **principles of radiation protection** will be held at the Harwell Reactor School (England) from 25 October 1961 to 30 January 1962. The course is intended for graduates or persons of graduate standard who are planning to enter, or are presently working in, the field of radiological health and safety. Previous specialized knowledge is not required. Tuition: £250. (Manager, Reactor School, Atomic Energy Research Establishment, Harwell, Berkshire)

The second winter institute in **quantum chemistry and solid state physics**, to be held at the University of Florida, will consist of a preparatory week from 4 to 9 December; an introductory course from 11 to 30 December; and an advanced course from 2 to 13 January 1962. The program is arranged in collaboration with the University of Uppsala (Sweden), through the support of the National Science Foundation. Priority for admission and for the limited number of stipends available will be given those who apply *before 10 November*. (Director, Winter Institute, Department of Chemistry, University of Florida, Gainesville)

Grants, Fellowships, and Awards

A **medical TV travel grant** is available to a medical or dental school, not presently using television, which wishes to send a representative to visit an established health-science TV installation. Applications for the grant, made available by Blonder-Tongue Laboratories, must include the name and position of the designated representative and an outline of any specific plans for use of TV. Deadline: *31 October*. (Council on Medical Television, 33 E. 68 St., New York)

Applications are now being accepted for the 1962–63 **Lederle Medical Faculty awards**, intended only for individuals who are working in and contemplating further full-time academic careers in preclinical or certain clinical departments of medical schools. Recipients must hold the rank of instructor or assistant professor, or their equivalent, and are expected to enter fully into all departmental activities. The awards are not intended as research fellowships. Nominations must be endorsed by both the dean of the medical school and the administrative head of the sponsoring department. Deadline: *20 October*. (Lederle Medical Faculty Awards, Office of the Secretary, Pearl River, N.Y.)

Meeting Notes

The fourth annual conference on **science and technology in Israel and the Middle East**, sponsored by the American Society for Technion, will be held in New York on 14 and 15 October. (Bern Dibner, AST, Israel Institute of Technology, 1000 Fifth Ave., New York 28)

The 4th International Congress of **allergology** will be held from 15 to 20 October in New York. Papers may be presented in English, French, German, or Spanish, and will be simultaneously translated into the other official languages of the congress. (W. B. Sherman, Roosevelt Hospital, 428 W. 59 St., New York 19)

African education, science, culture, and communication are the main topics to be covered at the 8th national conference of the U.S. National Commission for UNESCO. The conference, to be held in Boston from 22 to 26 October, will be attended by over 50 African leaders and educators, in addition to representatives of national organizations. (Eugene Sochor, U.S. National Commission for UNESCO, Department of State, Washington 25, D.C.)

A 2-day meeting on **psychoanalytic education** will be held in New York on 9 and 10 December 1961. (Joseph H. Merin, Academy of Psychoanalysis, 125 E. 65 St., New York)

A symposium on **cystic fibrosis** will be held on 9 October at the New York Academy of Sciences. The proceedings, papers, and discussion of the meeting, sponsored jointly by the academy and the National Cystic Fibrosis Research Foundation, will be published as a special issue of the *Annals of the New York Academy of Sciences*. (NCFRF, 521 Fifth Ave., New York 17)

Scientists in the News

The following awards will be presented during the fall meeting of the American Institute of Electrical Engineers, to be held from 15 to 20 October in Detroit:

George F. Corcoran, of the University of Maryland, will receive the Electrical Engineering Education medal.

Samuel B. Griscom, of the Westinghouse Electric Corp., will receive the William M. Habirshaw award for his work in electric utility engineering.

Theodore A. Rich, of General Electric Company's Engineering Laboratories, will receive the Morris E. Leeds award for his work in measurement.

Harry Nyquist, retired Bell Telephone Laboratories engineer, will receive the Mervin J. Kelly award for his work in communication and control theories.

Charles H. Townes, a member of the U.S. Air Force Scientific Advisory Board, on leave from Columbia University, will receive the David Sarnoff award for his work in resonance physics.

Klaus Schwarz, head of the section on experimental liver diseases at the National Institute of Arthritis and Metabolic Diseases, has received the 1961 Borden award for "outstanding work in nutrition as it relates to milk or its constituents." The award is presented annually by the American Institute of Nutrition.

Joseph L. Gillson, retired chief geologist of the DuPont Company, has been named the first William Otis Crosby lecturer at Massachusetts Institute of Technology for the 1961–62 academic year.

R. Ruggles Gates, emeritus professor of botany at the University of London will spend 6 months as visiting professor at the Indian Statistical Institute in Calcutta.

John P. Howe, former research director at Atomics International, a division of North American Aviation, Inc., has been appointed professor of engineering at Cornell University.

William D. Neff, former professor of psychology and physiology at the University of Chicago, has been named director of the newly established psychophysiology department at Bolt Beranek and Newman, Inc., Cambridge, Mass.

Man's Circuitous Route to the Modern World

Mankind, endlessly restless, moves into and out of phases of civilization.

Robert H. Dyson, Jr.

The late anthropologist, Alfred Kroeber, in discussing the formation of cultures once wrote "Every culture is an accretion. . . . It is the end product of a long series of events occurring mostly in other cultures, accidents from its own point of view, but ultimately of influence upon it." The mechanics of such cultural development are admirably illustrated by the 13 pictorial chapters and essays presented in **The Dawn of Civilization** (McGraw-Hill, New York, 1961. 404 pp. $23.50, until 15 March 1962; then, $28.50), edited by Stuart Piggott.

Some of the contributing authors are already well known to readers of general works in the field of art and archeology by virtue of their own masterly contributions to that field; others, less widely known perhaps, now make a significant contribution through their synopses of regions hitherto neglected in Western literature. The combined result of these talents is a book which brings the prehistory of the major cultures of the Old World, in particular, into fresh focus for the general reader and which provides a broad orientation for the student and the teacher as well.

The format of this volume was inspired by a series of articles entitled "The Epic of Man" which appeared in *Life* magazine during 1955 and 1956. Greater coverage and much additional illustrative material in color and in black and white leads the reader through a logical progression in time and space: The hunters and gatherers of the Stone Age (Grahame Clark); The beginning of village and urban life (James Mellaart); Mesopotamia and Iran (M. E. L. Mallowan); Ancient Egypt (Cyril Aldred); The sea peoples of the Levant (William Culican); The early settlement of Anatolia (Seton Lloyd); The Aegean before the Greeks (M. S. F. Hood); Ancient India (Sir Mortimer Wheeler); China (William Watson); The diverse traditions of South East Asia (Anthony Christie); The nomad peoples of the steppes (E. D. Phillips); Barbarian Europe (T. G. E. Powell); and The birth and growth of New World civilization (G. H. S. Bushnell). An excellent introduction and an epilogue are provided by Stuart Piggott, the editor, along with a selected bibliography for each chapter and a list of the sources for the illustrations. Each chapter is introduced by a map of the area to be discussed and, where practical, by a comparative chronological chart of the cultures of related areas. The subtitle of the book, "The first world survey of human cultures in early times," promises somewhat more than is actually covered, since Africa outside Egypt is largely omitted, while the complexities of archeology in the New World are reduced to a single chapter. Nonetheless, through the inclusion of the cultural history of such areas as South East Asia, Central Asia, and Europe, the major centers of the Old World (Egypt, Sumer, the Indus, and China) are brought into relationship with one another and with their hinterlands in a way which, for once and for all, should show the inadequacy of the standard compartmental approach to ancient history.

The ebb and flow of thought and form between the areas described is constantly stressed in the selection of the many excellent colored plates and in the text: Sumerian cylinder seals appear in Egypt before 3000 B.C.; Indus valley script occurs on seals in Sumer around 2300 B.C.; socketed bronze celts are shared by southern Siberia and Shang China by 1200 B.C.; a Roman lamp turns up in Thailand in the 3rd century A.D., and so on. Mostly, such objects are trade items marking the route of more perishable goods carried by traveling merchants. With them moved a growing wealth of ideas and an increasing knowledge of the world at large. The process of shrinkage of the world, so visibly accelerating in the present day, had already begun.

The vast data of the study of prehistory are made logical and intelligible through a judicious choice of photographs, artists' reconstructions, and the chronological ordering of cultures within a geographical framework. At the same time the strangeness of the names, the condensed nature of the information, and its quantity will not make light or easy reading for the average reader. Perseverance on his part will, however, reap a rich reward in the general understanding of the circuitous route by which man has reached the modern world. Reading about this subject is made easier by the self-contained nature of each chapter; one is enabled to deal with the book a piece at a time without loss of comprehension. Each chapter presents the most recent evaluation of the problems it contains, as set forth by its particular author. The book as a whole, therefore, is an excellent introductory text, while at the same time it forms a major reference point for scholars. Each author has, of course, a different background, and as these backgrounds shift from anthropology to art history or ancient history, there is a corresponding shift of emphasis in the text. The editor, Stuart Piggott, is to be congratulated on holding these differences to a minimum. As a consequence he has produced a reliable and instructive text by virtue of having had an authority write each chapter, while maintaining a common standard for style and presentation which provides an over-all unity.

Much of this book would have been difficult, if not impossible, to write at the end of World War II. The fact that it has now been published is a measure of the progress which our study of mankind has made during these last years. Temporally, our horizons have been pushed farther and farther back by the remarkable fossil discoveries in Africa—the antiquity of man the tool-

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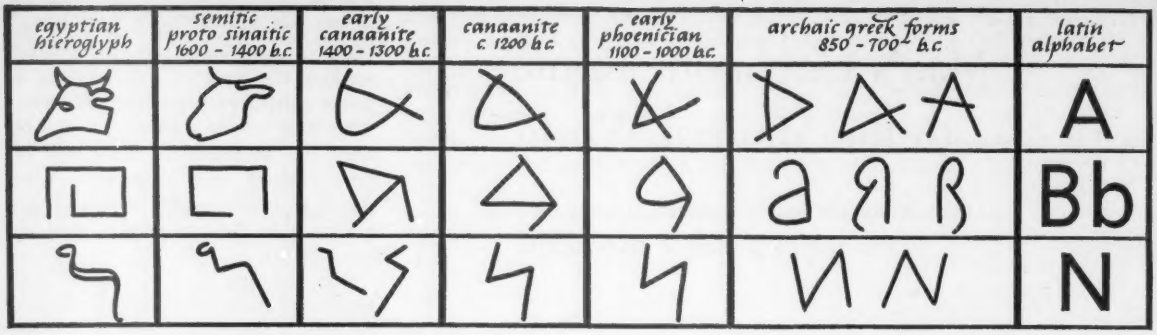

Fig. 1. Development of the alphabet. Diagram shows how *aleph* (an ox), *beth* (a house), and *nun* or *nahas* (a snake), evolved into the letters A, B, and N of our alphabet. [From *Dawn of Civilization*]

maker being perhaps more than twice as great as previously estimated, according to the latest atomic dating. Equally important, the beginnings of food production now appear to be two or three thousand years older than anyone would have dared to suggest 20 years ago. Spatial lacunae are also being filled, with the gradual application of modern excavation methods to India south of the Indus, Oceania, and so on. The continuing refinement of the established archeological yardsticks in major centers like the Indus, the north China plain, and the Near East allow the gradual integration of data from more marginal regions like central India, south China, and central Asia into the known picture. The result is the emergence of a view of the continental land mass of Eurasia as a functioning whole where events in one area lead to events in another. Indo-Europeans migrate from the Caucasus through Iran into India, changing the course of civilizations of the second and first millennia B.C. drastically; nomads flee the borders of an expanding Han China only to storm the frontiers of a belligerent Roman empire; Indonesians settle in Madagascar, bringing South East Asia to Africa. Mankind, endlessly restless for a multitude of reasons, is seen constantly on the move from place to place as well as into and out of phases of civilization.

Civilization Defined

The use of that word "civilization" brings to mind the title of the book and leads one to ask just what it is that is "dawning." For an answer we may turn to Piggott's introduction. "In this book," he says, " 'civilization' is used to mean a society which has worked out a solution to the problem of living in a relatively large permanent community, at a level of technological and social development above that of the hunting band, the family farmstead, the rustic self-sufficient village or the pastoral tribe. Civilization is something artificial and man-made, the result of making tools of increasing complexity in response to the enlarging concepts of community life evolving in men's minds" (page 11). Equally succinct is Wheeler's statement in the chapter on the Indus: "Civilization, in a minimum sense of the term, is the art of living in towns, with all that the condition implies in respect of social skills and discipline. . . . More particularly, it is held to include a systematic method of accounting, so that revenue and wages may be adequately registered, and orderly government ensured. *Writing*, in some form or other is on this view a pre-supposition" (page 243). And he adds a comment to the effect that writing should not be overemphasized to the detriment of the achievement of nonliterate peoples. (After all, most of the great technological discoveries in the periods covered occurred before the invention of writing: grinding and polishing of stone; pottery; the wheel; domestication of plants and animals; the use of copper, gold, and lead; boats and the sail; brick architecture; spinning and weaving; and so on.) As a means of making "civilization" objective for archeological purposes, the use of the appearance of writing in conjunction with the remains of urban living is convenient. By admitting writing as a major criterion of civilization archeologists follow the lead of the 19th century anthropologists Tylor and Morgan, who originally proposed it as the basis for differentiating an earlier stage of "Barbarism" from a later stage of "Civilization." The importance and connection of writing with urban life in its early stages is made more explicit by Mallowan in discussing Mesopotamia. "Trade, the organization of labor, sustenance of the people, cultivation of the land, required an elaborate social organization and a bureaucracy capable of maintaining records of its transactions. The necessity of establishing title to property, close supervision over the distribution of goods, the care of rations for all kinds of workers employed by the state could not have been systematically organized in these expanded communities without the aid of written records. The invention of writing was therefore indispensable to the concentration of life in cities" (page 83). The uses to which writing was put, who understood the writing and had access to it, and how it evolved are long stories in themselves. From the first pictographic signs (see Fig. 1) through intermediate scripts to the alphabet was a period of nearly 2000 years; from the first pictographic inventories to known connected historical records was a matter of nearly 1000 years; while universal literacy is a goal toward which the world still struggles, some five millennia later.

The operational definition of "civilization" adopted by archeologists (urban existence plus writing) pinpoints a specific time and place where "civilization" first occurred; namely, in the Uruk period in southern Mesopotamia, just prior to 3000 B.C. Significantly, the primitive condition of writing leaves us uninformed as to the ideological content of the culture at this important moment. The full light of history follows quickly, however, as does the

birth in quick succession of civilization in Egypt, India, and China. The sharp contrast between the precivilized and the civilized worlds from our vantage point is neatly drawn by Seton Lloyd. "The clear historical character of this later period, the evidence of political development and religious thought, the sequence of royal names and the battles or treaties associated with them, all serve by contrast to emphasize the drab impersonality of the 'archaeological' ages which preceded it, where the biography of a nation can be written only in terms of broken pottery and the discarded belongings of its most humble artisans. Yet, even in this obscure half-light of 'material cultures' and 'racial criteria', . . . brief moments of illumination do intermittently occur" (page 185).

Illuminating, Brief Moments

The pictorial parts of *The Dawn of Civilization* provide an assemblage of many such "brief moments of illumination" in our knowledge. The sum total of the 940 illustrations underlines the astonishing richness of the human imagination, faced with a multitude of environments and varying amounts of knowledge, in its ability to represent in material form the world of reality as well as the equally important world of dreams. Most philosophers would probably agree that while the birth of civilization is important, the birth of imagination and the consequent world of thought is even more fundamental to the human condition. Regretfully, the early stages of this obviously rich landscape of the mind are largely lost to us. Yet, even so, from the multitude and complexity of the objects set before us in this volume something of its quality and meaning may be inferred. The anthropologist, Loren Eiseley, describes this "dream world" in one of his essays. "It was a weird multiheaded universe, going on, unseen and immaterial save as its thoughts smoldered in the eyes of hunters huddled by night fires, or were translated into pictures upon cave walls, or were expressed in the trappings of myth or ritual. The Eden of the eternal present that the animal world had known for ages was shattered. . . . Through the human mind, time and darkness, good and evil, would enter and possess the world."

Earth's Yesterday

History of the Earth. An introduction to historical geology. Bernhard Kummel. Freeman, San Francisco, Calif., 1961. xiv + 610 pp. Illus. $8.75.

Has the geology instructor ever been confronted by so many new textbooks on historical geology? Moore's *Introduction to Historical Geology* (1958), the veteran among the five, is still valuable. Distribution maps, correlation charts, the wealth of photographs and diagrams, and the mature treatment of the material make it a good classroom and a good reference book. To my mind, Dunbar's *Historical Geology* (1960) is too simple and easy, largely because it avoids the interesting problems. Stokes' *Essentials of Earth History* (1960) is very strong on the organic side, with excellent chapters on evolution, migration, and similar subjects. Clark and Stearn's *Geological Evolution of North America* (1960) is the first truly regional text published in some 30 years; the diagrams alone make it tempting.

As a traditional text, Kummel's book has unusually full introductory chapters as well as an excellent treatment of the Paleozoic, Mesozoic, and Cenozoic eras of North America and of the life of those eras. But what is new and different in Kummel?

This is the first textbook to give the history of all continents, rather than just that of North America. Now we have an over-all view. No longer are we trapped in the Appalachian geosyncline—we see what is happening at the same time in other parts of the world. Nor are we misled into thinking that the Triassic is all red and nonmarine; Tethyan history is enlightening. The Cenozoic of the Alps, the Himalayas, and the Philippines is treated briefly but exceedingly well. These chapters are valuable both for current study and for permanent reference.

Also completely new is the chapter "Gondwana formations." Discussion ranges widely, from rock type to glaciation, from *Glossopteris* flora to paleomagnetism. The chapter is a marvel of condensation and completeness and an outstanding example of what a "problem chapter" should be.

Throughout the text the unifying theme is "evolution and interrelations of mobile and immobile belts." Local detail is held to a bare minimum, and attention is focused first on geosynclines and then on stable areas. This is not new, but it is clearly and consistently worked out.

Also, the author has brought in a wealth of new material or has revitalized the familiar. Examples are: the history of the ammonoids (pages 215–16 and 287–92); geographic range of fossil reefs (pages 296–97); Pleistocene climates (pages 468–78); and the extended account of the evolution of man (pages 483–505).

Not everything in the book meets with my approval. I think the author has gone completely overboard in favor of "tectonism"; I wonder why there are eugeosynclines on only the maps of North America. I regret that we are told nothing about the "how" of oil in the Middle East. Also, the next edition must have more extensive bibliographies, especially for students. I can find out what "G. G. Simpson, 1953" refers to (in Fig. 14-36, page 465), but a first-year student, or even a more advanced one, needs encouragement to look up anything.

Which book to choose? If you are already using a familiar, straightforward text, without complications, you may want to stick to it. If you want a challenging, somewhat difficult text, one that everywhere shows the intelligence and learning of its author, a complex book with many facets, then you must consider Kummel's volume.

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Sherborn's Index Extended

An Index to the Genera and Species of the Foraminifera, 1890–1950. George Vanderbilt Foundation, Stanford University, Stanford, Calif., 1961. 393 pp. $10; unbound, $9.

This volume, which is similar in style to the annual indexes published by Hans Thalmann for many years, provides students of the Foraminifera with an invaluable tool, for it covers all newly proposed generic and specific names that appeared in the literature between 1890 and 1950.

In 1955 the Smithsonian Institution reprinted Charles Davies Sherborn's *An Index to the Genera and Species of the Foraminifera.* Sherborn's volume, long

out of print and difficult to find, covered the genera and species described through 1889, but the lack of complete coverage of the literature published after 1890 remained a serious handicap for workers in the field. Students of Foraminifera now owe a debt of gratitude to Thalmann for continuing the earlier work of Sherborn and completing an index of genera and species for the 60-year period 1890 through 1950 and to the George Vanderbilt Foundation (Stanford University) for undertaking publication of the important volume. The index is published in an attractive, well-printed, double-column, quarto volume. The following data are given for generic names: reference, type species, family assignment, and geologic age; for species: reference, geologic age, and area from which described. The generic and specific names are printed in boldface type. Some references for years prior to 1890 are given when they were not included in the Sherborn index.

Complete coverage of the well-scattered literature on Foraminifera published through 1950 is now available.

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Selected Overview

Recent Advances in Human Genetics. L. S. Penrose, Ed. Little, Brown, Boston, Mass., 1961. 194 pp. Illus. + plates. $8.

In a field developing as rapidly as human genetics, it would be impossible to handle all recent advances adequately in one volume. As an alternative, Penrose has chosen to select eight specific areas for careful treatment. His choice is excellent, and the style of writing is surprisingly uniform for a book with several contributors. The volume as a whole can be described as illustrative and concise, rather than as exhaustive and detailed.

Each chapter presents an overview of a specific problem, with comments about its historical development and the proper use of relevant terms. Significant principles are stated clearly and illustrated well. Some of the most recent findings are summarized, and the nature of current research problems is indicated.

Readers interested in clinical implications of genetics will appreciate Harnden's discussion of techniques and results in chromosome studies and the review of normal and abnormal sex differentiation by Miller. Penrose points out that birth weight can be studied profitably from the statistical and genetical points of view, and he also reviews the interaction of genetic and environmental factors in congenital malformations. Topics in human biochemical genetics are deliberately omitted in view of their adequate treatment elsewhere.

Statistical methods and theory are discussed by Smith, with an emphasis on procedures for analyzing genetic ratios, gene frequencies, and segregation ratios. Renwick presents a very clear review of methods and results in the study of linkage. At present only three autosomal linkages can be accepted with confidence, and only color-blindness loci are generally useful as sex-linked markers. Penrose outlines assumptions and procedures used in estimating mutation rates and stresses sources of bias which can lead to exaggerated values. Analysis of fingerprint patterns (discussed by Holt) reveals the strong effect of heredity upon pattern size and provides an interesting model for the study of quantitative traits in man.

Gerald's survey of abnormal hemoglobins has clinical implications, but it also highlights some insights and puzzles concerning the genetic determination of complex protein structure. Both qualitative and quantitative alterations in hemoglobin synthesis are described, and genetic interrelationships among the variants are interpreted. Other implications for understanding gene structure and action are included in the chapters on mutation, chromosomes, and linkage.

This book should appeal to a wide variety of readers. Interested laymen and scientists in fields other than genetics will find it a readable and authoritative starting point for understanding the topics discussed. Graduate and medical students and physicians will profit from the clear statement of basic principles and assumptions, as well as from the review of current techniques. For those who wish further details, there is a list of over 500 references (about half are later than 1955).

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On Science and the Scientist

Atoms and Men. Louis Leprince-Ringuet. University of Chicago Press, Chicago, Ill., 1961. 118 pp. $3.

The title page describes this book as a "translation," but it nowhere appears whether this is a translation of a book originally published in France, or whether we have here a translation made directly from an original French manuscript.

The author is director of the laboratory at the École des Hautes Études and is an atomic energy commissioner of France. The book is primarily addressed to the Frenchman who has suddenly become aware (and who is disturbed by all the implications of this awareness) that an absolute condition for the greatness or even the survival of a modern nation is that the nation take its place among the nuclear powers. One section is entitled "Can France Stage a Comeback?" The Frenchman has to take account of two different sorts of things, if he is to understand the implications of becoming a nuclear power. He must understand, as far as possible, the factual scientific background, and he must also understand what manner of man the scientist is to whom the destinies of his country will have to be increasingly entrusted. The author tries to accomplish both these ends by a popular, almost chatty, method of approach. It is somewhat surprising that nowhere in the book is there any explicit mention of the recent French decision to construct their own atomic bomb.

The translation reads smoothly enough, but one cannot help questioning the technical competence of the translator, when confronted with a passage like this (page 103): "It [uranium] is extremely *thick*." The context does not indicate whether "thick" means density or atomic weight. One's confidence in the technical competence of the author himself is somewhat shaken when confronted by: "We know, of course, that one can ascertain the mass of a marble or projectile by throwing it at a certain speed and then spotting the place where it falls" (page 6). And one does not know whether to question the technical competence of the author or of the translator when confronted by: "The piles of projectiles for an accelerator called a bevatron were ready" (page 24). One can only wonder to

what extent the author had his tongue in his cheek throughout the entire book, in view of his remark on page 31: "But make no mistake; one can quite readily become an excellent physicist even if one's intellectual faculties are not highly developed."

The final chapter, "The atomic scientist and the believer," seems quite uncalled for and has no apparent connection with the rest. One wonders whether there is in France an intransigent core of fundamentalists who have to be appeased in some way.

All in all, in spite of its lively style and not infrequent flashes of insight, the book leaves an unpleasant taste.

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Birds, Bees, and Good Society

Communication among Social Bees. Martin Lindauer. Harvard University Press, Cambridge, Mass., 1961. 143 pp. Illus. $4.75.

The Herring Gull's World. Niko Tinbergen. Basic Books, New York, ed. 2, 1961. 255 pp. Illus. $5.

These books are about similar subjects, and you can more than double your enjoyment by reading them one after the other, for then there is the added pleasure of contrasting both the authors and their favorite animals.

Lindauer was a student of Karl von Frisch. And this book carries further the studies summarized in von Frisch's wonderful *Bees: Their Vision, Chemical Senses, and Language*. Lindauer continues by asking specific questions about the society of the honeybees. First he asks how the work is divided among the inhabitants of the hive. He approached the question by watching individual bees, night and day, with stop watch in hand, until he had a detailed time-motion study. Bee No. 107, observed for 177 hours, spent all of 69 hours and 53 minutes just loafing. Between rests, she frequently strolled through the hive, not aimlessly it seems, but on patrol to see which chores—cell cleaning, brood tending, guarding, and the like—needed doing. In the hive, labor is organized by the workers coming across something that has to be done and then doing it, not by directives from above.

Lindauer goes on to consider communication among the bees. In the heat of summer, the bees cool the hive, as much as 35° centigrade, by sprinkling water over the brood cells. Water is fetched to the hive by the older, foraging bees. The number of trips made by the foragers is determined by how quickly the hive bees take the water load. This relationship is demonstrated on a graph in which the number of collecting flights is plotted as a function of the time taken to deliver the water load. When the delivery time is less than 40 seconds, the foragers also give an "alerting" dance, to recruit others to the work. This kind of careful measurement is the mark of von Frisch passed on to his student.

Next Lindauer asks how a swarm of bees selects a new site for a hive. It turns out that the scouts report by means of a dance which shows the direction, the distance, and the quality of a proposed site. The swarm remains, for days if necessary, in temporary quarters until the scouts reach a consensus on the best possibility, then the whole swarm moves off to the new site. These are just samples of the book's contents. Lindauer also discusses the evolution of communication in honeybees, which he studied by observing other species of bees, and some of the sensory and computational problems involved in using the sun as a reference point for the well-known food collecting dances. One fascinating discovery is that bees which have been raised in a cellar under artificial light need to practice for some days before they can navigate by the sun. They must learn how the sun moves. But after seeing the arc of the sun only in the afternoon, they can navigate in the morning on the first try.

Tinbergen's book has a broader goal. For years he watched with infinite, patient care the day-to-day life of the herring gull. His aim was to understand the significance of every movement and of every call and to see how the somewhat rudimentary society of the gullery is organized. Tinbergen's conclusions are drawn mostly from field notes; the relatively few experiments reported here were also discussed in his *Study of Instinct*. The focus of *Herring Gull's World* is not on the experimental analysis of behavior; the volume is, in the finest sense, a work of natural history. He pays particular attention to reproduction and rearing of the young, from the first arrival at the gullery, the establishment and defense of the territories, pair formation, incubation, and the feeding and behavioral development of the chicks. The present book is a slightly revised edition of the work first published in 1953.

These books by Tinbergen and Lindauer are clearly separated by aspiration and by method. Undoubtedly Lindauer's approach is more satisfying to the experimental scientist; we know the questions, the observations, and the numerical results. On the other hand, Lindauer's questions are based on generations of observation of life in the bee hive, exactly the sort of natural history that Tinbergen provides for the herring gull. Both types of work are necessary, and the two books are perfect examples of two levels of scientific exploration. It is somewhat amusing, however, to see that Tinbergen reaches far more sweeping conclusions about behavior in general.

Perhaps in these books there are also line-by-line hints of how the authors' temperaments determine their approach. Tinbergen loves his birds, he delights in their motions and abilities, he writes of them with joy and verve—and his enthusiasm is catching. He also tells a good deal about Niko Tinbergen—every reader will want to meet the charming author. Lindauer writes with precision. He leaves untold his adventures encountered in following bees from Germany to Ceylon to South America; the excitement comes from the subject itself. Both books are well illustrated.

A comparison between the animals only re-emphasizes the astounding complexity of the bees, whose behavior puts most vertebrate societies to shame.

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New Books

Biological and Medical Sciences

British Flies. Empididae. J. E. Collin. Cambridge Univ. Press, New York, 1961. 227 pp. Illus. + plate. $6.

The Cell and the Organism. J. A. Ramsay and V. B. Wigglesworth, Eds. Cambridge Univ. Press, London, 1961. 357 pp. Illus. $9.50.

The Ciliated Protozoa. Characterization, classification, and guide to the literature. John O. Corliss. Pergamon, New York, 1961. 310 pp. Illus. + plate. $12.

Contributions to the Systematics of Oriental Termites. M. L. Roonwal and P. K. Sen-Sarma. Indian Council of Agricultural Research, New Delhi, 1960. 420 pp. Illus. + plates. $9.

The Extra Pharmacopoeia Martindale. Supplement 1961 to vol. 2, ed. 23 (1955), and vol. 1, ed. 24 (1958). Pharmaceutical Press, London, 1961. 324 pp. $6.50.

Faune de France. 65. *Poissons d'Eau Douce*. Charles Jacques Spillmann. Lechevalier, Paris, 1961. 303 pp. Illus.

Mammals of the Southwest Mountains and Mesas. George Olin. Southwestern Monuments Assoc., Globe, Ariz., 1961. 141 pp. Illus. Paper, $2; cloth, $3.25.

The Mites of Stored Food. Ministry of Agriculture, Fisheries, and Food, Technical Bulletin No. 9. A. M. Hughes. Her Majesty's Stationery Office, London, 1961 (order from British Information Services, New York 20). 293 pp. Illus. $3.30.

Physiological Responses to Hot Environments. MRC Special Report, No. 298. Compiled by R. K. MacPherson. Her Majesty's Stationery Office, London, 1960. 338 pp. Illus. $6.55.

The Salmon. J. W. Jones. Harper, New York, 1959. 208 pp. Illus. $4.50.

Physiology of Plants. P. Font Quer. Harper, New York, 1960. 126 pp. $2.25.

Pioneer Microbiologists of America. Paul F. Clark. Univ. of Wisconsin Press, Madison, 1961. 383 pp. $6.

Progress in Industrial Microbiology. vol. 3. D. J. D. Hockenhull, Ed. Interscience, New York, 1961. 237 pp. Illus. $8.50.

The Spinal Cord. Basic aspects and surgical considerations. George Austin. Thomas, Springfield, Ill., 1961. 546 pp. Illus. $26.50.

Stedman's Medical Dictionary. Williams and Wilkins, Baltimore, Md., 1961. 1680 pp. Illus. + plates. $14.95.

A Survey of the Dragonflies (Order Odonata) of Eastern Africa. E. C. G. Pinhey. Clowes, London, 1961. 221 pp. 50s.

Synopsis of Histology. Henry J. Werner. McGraw-Hill, New York, 1961. 156 pp. $4.25.

Toxicology. Mechanisms and analytical methods. vol. 2. C. P. Stewart and A. Stolman, Eds. Academic Press, New York, 1961. 937 pp. Illus. $25.

Vitamins and Hormones. Advances in research and applications. vol. 18. Robert S. Harris and Dwight J. Ingle, Eds. Academic Press, New York, 1960. 629 pp. Illus. $15.

Weed Control. As a science. Glenn C. Klingman. Wiley, New York, 1961. 429 pp. Illus. $8.50.

Economics and the Social Sciences

An Introduction to Psychoanalytic Theory of Motivation. Walter Toman Pergamon, New York, 1960. 365 pp. $9.

Life and Ritual in Old Siam. Three studies of Tai life and customs. Phya Anuman Rajadhon. Translated and edited by William J. Gedney. HRAF Press, New Haven, Conn., 1961. 191 pp. Illus. Paper, $4.50.

Man in Process. Ashley Montagu. World, Cleveland, Ohio, 1961. 313 pp. Illus. $4.50.

The Political Kingdom in Uganda. A study of bureaucratic nationalism. David E. Apter. Princeton Univ. Press, Princeton, N.J., 1961. 514 pp. Illus. + plates. $10.

A Rorschach Reader. Murray H. Sherman, Ed. International Universities Press, New York, 1960. 456 pp. Illus. $7.50.

General

The Biblical Archaeologist Reader. G. Ernest Wright and David Noel Freedman, Eds. Quadrangle Books, Chicago, Ill., 1961. 358 pp. Illus. $6.75.

A Catalogue of Instruments and Models in the Posession of the American Philosophical Society. Robert P. Multhauf. American Philosophical Society, Philadelpha, Pa., 1961. 91 pp. Illus. $1.50.

Cybernetics. Or control and communication in the animal and the machine. Norbert Wiener. M.I.T. Press and Wiley, New York, ed. 2, 1961. 228 pp. Illus. $6.50.

Dinosaurs. Their discovery and their world. Edwin H. Colbert. Dutton, New York, 1961. 314 pp. Illus. $7.50.

European Military Museums. A survey of their philosophy, facilities, programs, and management. J. Lee Westrate. Smithsonian Institution, Washington, D.C., 1961. 215 pp. Illus.

I Can Learn about Calculators and Computers. Raymond G. Kenyon. Harper, New York, 1961. 112 pp. Illus. $2.95.

Writing a Technical Paper. Donald H. Menzel, Howard Mumford Jones, and Lyle G. Boyd. McGraw-Hill, New York, 1961. 141 pp. Illus.

Mathematics, Physical Sciences, and Engineering

Advances in Electronics and Electron Physics. vol. 14. L. Marton, Ed. Academic Press, New York, 1961. 351 pp. Illus. 88s.

Axial Flow Fans. Design and practice. R. A. Wallis. Academic Press, New York, 1961. 375 pp. Illus. $10.

Azo and Diazo Chemistry. Aliphatic and aromatic compounds. Heinrich Zollinger. Translated by Harry E. Nursten. Interscience, New York, 1961. 444 pp. $16.50.

Calculus. George B. Thomas. Addison-Wesley, Reading, Mass., 1961. 863 pp. Illus. $8.75.

Colorimetric Methods of Analysis. Including photometric methods. vol. 3A. Foster Dee Snell and Cornelia T. Snell. Van Nostrand, Princeton, N.J., 1961. 586 pp. Illus. $10.75.

Columbium Metallugy. D. L. Douglas and F. W. Kunz, Eds. Interscience, New York, 1961. 762 pp. Illus. $26.

Concepts in Electricity and Magnetism. Reuben Benumof. Holt, Rinehart and Winston, New York, 1961. 384 pp. Illus. $5.75.

Crossed-Field Microwave Devices. vols. 1 and 2. E. Okress *et al.*, Eds. Academic Press, New York, 1961. Illus. 670 pp., $22; 542 pp., $18.

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Reports

Generalized Neocortical Responses and Corticospinal Neuron Activity

Abstract. Long-latency responses evoked by ipsilateral sciatic nerve and hippocampal-fornix stimulation in barbiturized cats are associated with activation of corticospinal neurons. Differences in latency and configuration of generalized responses and patterns of relayed corticospinal neuron discharges indicate that a variety of extrathalamic projections are involved in activation of Betz cells.

The existence of extrathalamic centripetal pathways to neocortex was originally inferred from data on the mode of propagation and distribution of long-latency generalized "secondary discharges" to peripheral nerve or brainstem stimulation in barbiturized animals (*1*, *2*). Despite the fact that these evoked responses may be of extraordinary magnitude in sensorimotor cortex, it has been suggested that they are not associated with discharges of pyramidal neurons that give rise to the corticospinal tract (*3*).

The present study, part of a series of investigations on the regulation of corticospinal neuron activity by nonspecific projection systems (*4*), was undertaken to define the relationship between corticospinal neuron activity and two varieties of long-latency generalized neocortical responses: secondary discharges and the responses described by Morison, Dempsey, and Morison that follow stimulation of "the corpus callosum or the immediately subjoined fibers of the fornix system" (*2*). The present study establishes that the latter responses are attributable to stimulation of the hippocampal-fornix system.

Experiments were performed on adult cats maintained at various depths of anesthesia by repeated injections of small amounts of thiopental sodium. The animals were prepared for recording of long-latency responses evoked in motor cortex by stimulation of the ipsilateral sciatic nerve and direct stimulation of the exposed ventricular surface of the dorsal hippocampus, fimbria, or fornix. Corticospinal neuron activity was recorded with 100-μ Teflon coated wires inserted into the medullary pyramidal tract or by means of extracellularly located saline-filled micropipettes in the motor cortex. Betz cells were identified by high-frequency (250 per second) stimulation of the medullary pyramidal tract.

The results summarized in Fig. 1 indicate that long-latency (35 to 80 msec) responses in anterior sigmoid gyrus (motor cortex) evoked by ipsilateral sciatic stimulation under moderately deep thiopental anesthesia were associated with temporally dispersed relayed corticospinal tract discharges (Fig. 1, *A–B*), as well as low-frequency discharges of Betz cells (Fig. 1, *D–F*). Betz cell discharges were usually superimposed on various components of evoked subsurface focal long-latency responses that were predominantly negative in configuration.

Subsurface focal responses were complexly related to secondary discharges recorded from the surface of the motor cortex, as were discharges of single Betz cells. Discharge frequencies of the latter elements ordinarily did not exceed 10 per second. Although the number of discharges in a particular response sequence was rarely greater than three or four, frequently a unit might fire once during the subsurface focal response or not at all.

Like the secondary discharge evoked by stimulation of the sciatic nerve, very long-latency responses elicited by direct stimulation of the exposed hippocampus, fimbria, or fornix were also associated with relayed discharges in the corticospinal tract (Fig. 1*C*). As pointed out by Morison, Dempsey, and Morison (*2*), such generalized neocortical discharges were similar but not identical in wave form and cortical distribution to evoked secondary discharges. Hippocampal-evoked generalized discharges were best obtained at deeper levels of barbiturate narcosis than those required for eliciting maximal secondary discharges. Under optimum conditions for demonstrating both varieties of long-latency generalized responses, associated relayed corticospinal tract volleys might be of equal magnitude despite the fact that hippocampal-evoked tract discharges were twice the latency of those elicited by ipsilateral sciatic nerve stimulation (Fig. 1, *B–C*).

Corticospinal neuron discharges were related to early components of sciatic-evoked secondary discharges in pericruciate cortex when the latter were of maximum amplitude and predominantly positive-negative in configuration.

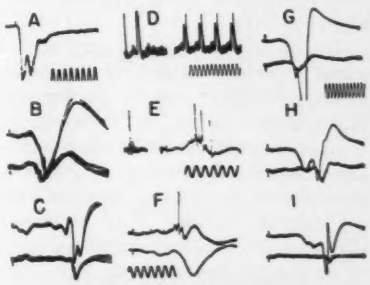

Fig. 1. (Three different experiments illustrated in *A–D*, *D–F*, and *G–I*.) *A*, Corticospinal tract discharges recorded in the medullary pyramidal tract following weak motor cortex stimulation; time calibration, 1000 cy/sec. *B* (upper channel), Secondary discharges recorded monopolarly from surface of motor cortex following ipsilateral sciatic nerve stimulation (0.5 per second). B (lower channel), Associated corticospinal tract discharges recorded as in *A*. *C* (upper channel), Surface responses to fimbrial stimulation recorded as in *B*. *C* (lower channel), Associated corticospinal tract volleys. Calibrations for *B* and *C* as in *A* but 100 cy/sec. *D*, Betz cell in motor cortex activated by 25 per second (left) and 250 per second (right) stimulation of medullary pyramidal tract. Calibration, 1000 cy/sec. *E*, Same unit as in *D*; (left), antidromic stimulation; (right), ipsilateral sciatic nerve stimulation. Calibration, 100 cy/sec. *F*, Betz cell discharge and surface-evoked secondary discharge to ipsilateral sciatic stimulation. Calibration, 100 cy/sec. *G–I*, Secondary discharges in motor cortex (upper channel) and relayed pyramidal tract volleys to ipsilateral sciatic nerve stimulation. Explanation in text. Calibration, 100 cy/sec.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

During the relatively brief period in which it was possible to maintain a steady level of moderately deep thiopental anesthesia, secondary discharges evoked by 0.5 per second ipsilateral sciatic nerve stimulation were unaltered in latency and configuration (Fig. 1*B*). At deeper levels of narcosis the *first* of a train of 0.5 per second stimuli evoked a maximal secondary discharge and relayed tract activity associated with the surface-positivity of the motor cortex response (Fig. 1*G*). Successive stimuli elicited secondary discharges of longer latency and complexity which were associated with marked increases in the latency of relayed tract responses (Fig. 1*H*). Under these conditions, corticospinal tract volleys, though considerably reduced in magnitude, were associated with a prominent very long-latency (150 msec) triphasic component of the cortical surface secondary discharge which evolved during repetitive (0.5 per second) stimulation (Fig. 1*I*). At this stage, secondary discharges were completely different in wave form from those recorded initially (Fig. 1*G*).

The finding that long-latency, generalized responses initiated by peripheral stimulation reflect activity in synaptic organizations linked to corticospinal neurons indicates that diffusely projecting *extrathalamic* pathways play an important role in the regulation of the corticospinal system. That a multiplicity of extrathalamic pathways may be involved in this regulation is evident from the variability of secondary discharges and associated relayed corticospinal tract discharges observed at different levels of barbiturate narcosis. In view of this, it is likely that such pathways may mediate effects on corticospinal neurons that have been reported to follow stimulation of diffuse peripheral fields under different experimental conditions (*5*).

Evidence is also presented here that diffusely projecting centripetal pathways activated by hippocampal efferents are capable of initiating corticospinal neuron discharges. This would appear to extend the range of action of archicortical efferent projection systems in the modulation of neocortical activity to a degree which has been previously unsuspected (*6*).

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8 June 1961

Behavior Studies by Capacitance Sensing

Abstract. The movements of small burrowing animals submerged in sand are monitored through capacitance changes which detune radio-frequency oscillators. A new dimension of reptilian activity studies is possible by using this technique. Some early observations of several reptile species maintained in darkness in isothermal sand are given. Patterns of behavior during active phases, depth and rate of diving, and duration of quiescent periods are being revealed in detail for the first time.

The capacitance-sensing technique provides a potentially valuable tool for the ethologist and ecologist. Although the method is highly versatile, it apparently has not been used heretofore to study animal movements. One application of this technique is illustrated; extensions to other uses will suggest themselves readily.

Our initial studies have dealt with burrowing reptiles of the genera *Chionactis, Chilomeniscus, Anniella*, and *Leptotyphlops*. A wide variety of other lizards and snakes burrow with great facility in loose sand or soil. In desert regions, such burrowing animals often spend a large part of each day buried beneath the surface. It has been suspected that their subsurface stay is not always a simple quiescent period, but may involve movements related to temperature stratifications (*1*), food searching (*2*), or selection of moisture levels (*2*). The data relating to these suppositions are fragmentary and have resulted from observations of (i) humped-up surface soil or sand displaced by the shallowly buried animal (*3*), (ii) animals submerged in glass-walled chambers and occasionally revealing themselves by pressing against the panes (*1, 2*), or (iii) the actual depths of buried animals uncovered by excavation (*4*). These methods give only a very incomplete picture of subsurface activity. A continuous monitoring method, allowing the investigator to detect the position of an animal constantly, is needed.

Capacitance sensing seemed most likely to fulfill this requirement. The method depends upon the production and detection of changes in capacitance of a regenerative radio-frequency oscillator. In the present application, the capacitance changes are brought about by the approach or contact of reptiles with a buried sensing element coupled with the oscillator condensers. Since the dielectric constant of sand is quite low (about 4), while that of animals is relatively high, the capacitance changes generated in this way are sufficient to make the method practicable.

Capacitance sensing has a number of advantages over other possible techniques: it is exceedingly sensitive (being able to detect large animals at distances over 15 inches); the sensing elements can be structured in any way desired; the geometry of the enclosure and environment is more or less immaterial; the experimental animals are undoubtedly insensitive to minute electrostatic fields oscillating at radio frequencies.

The enclosure illustrated in Fig. 1*A* was adopted after numerous trials. Its internal dimensions are 2½ × 18 × 46 inches. The ¼-inch Plexiglas side panels are held in position by ¼ × ¼-inch sand-tight grooves from which they are removable from above by sliding. External supporting structures are of wood.

The sensing and ground elements consist of linear grids of 24-gauge tinned copper wire strung back and forth with a horizontal spacing of ¼ inch. We have no reason to believe that the grids hamper free passage. Ten grids are spaced 4 inches apart, beginning 1 inch above the base. The grid-wire ends are fastened to binding posts on one side. These posts also serve as jacks to receive the oscillator lead-cables and grounds. The first, fourth, seventh, and tenth grids are used as sensors; the others are isolating grounds which reduce field coupling. The ground shield of each coaxial lead-cable is connected to both adjacent ground grids (except for the top and bottom shields).

For runs with an uncompacted fill, sand is poured into the chamber to the

desired level (usually 1 inch above the top grid). Sand stratified in this way can be compacted up to 10 percent by several sharp blows on the base of the chamber. At the end of a run, the sand is drained through outlets in the base. The final position of the animal can be ascertained at this time, for it usually resists the sand flow by clinging to the nearest grid.

Instruments Inc. Model B-04 oscillators (*5*) are employed. A regenerative radio-frequency oscillator of the Hartley type (Fig. 1*B*) is tuned into wide amplitude oscillation. The external sensing grid acts as a capacitance in series with the trimmer condensers. This series combination is effectively in shunt with the main fixed tuning condenser. When a burrowing animal touches or comes close to this grid, the capacitance of the tuned circuit is increased. A decrease in the amplitude of oscillation results, owing to interference in the coupling between the cathode and grid circuits of the 6SQ7 oscillator tube. As a result, current drawn by the diode plates of the 6SQ7 increases, with a consequent overriding of the bias of a thyrotron. This triggers a relay to deliver an on-signal to the corresponding channel of an Esterline-Angus Event Recorder. False detuning of oscillators, caused by internally or externally generated power-line transients, can be eliminated by buffering the oscillators with line-voltage regulators.

The oscillators are tuned individually after the chamber has been filled with sand. The unit is then allowed to equilibrate for several hours and retuned before introducing the animal. Tuning may have to be readjusted during a run in which loose sand is employed, because sand compaction resulting from movements of the animal usually increases the dielectric constant of the fill. Tuning is carried out by readjusting the trimmer condensers of the oscillator tank circuit. We have sought to obtain position signals primarily on contact of experimental animals with the sensing grids. With this objective the most sensitive setting is unnecessary. Tuning is calibrated by consecutively contacting each sensing grid with two calibers of machine bolts mounted on Plexiglas rods. It is easy to tune the oscillators to fire the thyrotron on contact of a given bolt with a binding post but not with the bolt of next size smaller. Even with this comparatively low sensitivity, an animal 9 or 10 inches long in contact with one sensing grid can detune a second oscillator by approaching but not contacting its sensing grid. This commonly occurs when the experimental animal burrows nearly vertically. Such a record is shown in Fig. 1*C*. Oscillators can also be detuned by near approach of an animal in contact with a ground grid.

Thus far, movements have been monitored only in darkness in isothermal sand at a temperature (23° to 24°C) assumed to be within the limits of the animals' normal activity temperature ranges. Tests are planned with diurnal temperature gradients coincident with a daily light cycle. In this way, we hope to simulate subsurface thermal events and to give essentially natural light cues. Behavior related to these factors should then become evident.

The tests in uncompacted isothermal sand show that the small colubrid snake, *Chionactis occipitalis*, and the limbless lizard, *Anniella pulchra*, are able to move up or down through the entire vertical depth of sand (38 inches) within as little as 7 minutes (Fig. 1*C*). Nearly every specimen of *A. pulchra* introduced into the chamber swam directly to the bottom. However, the patterns of movement are quite variable; they are interspersed with periods of quiescence, one of which lasted almost 45 hours (during which an oscillator was held continually detuned).

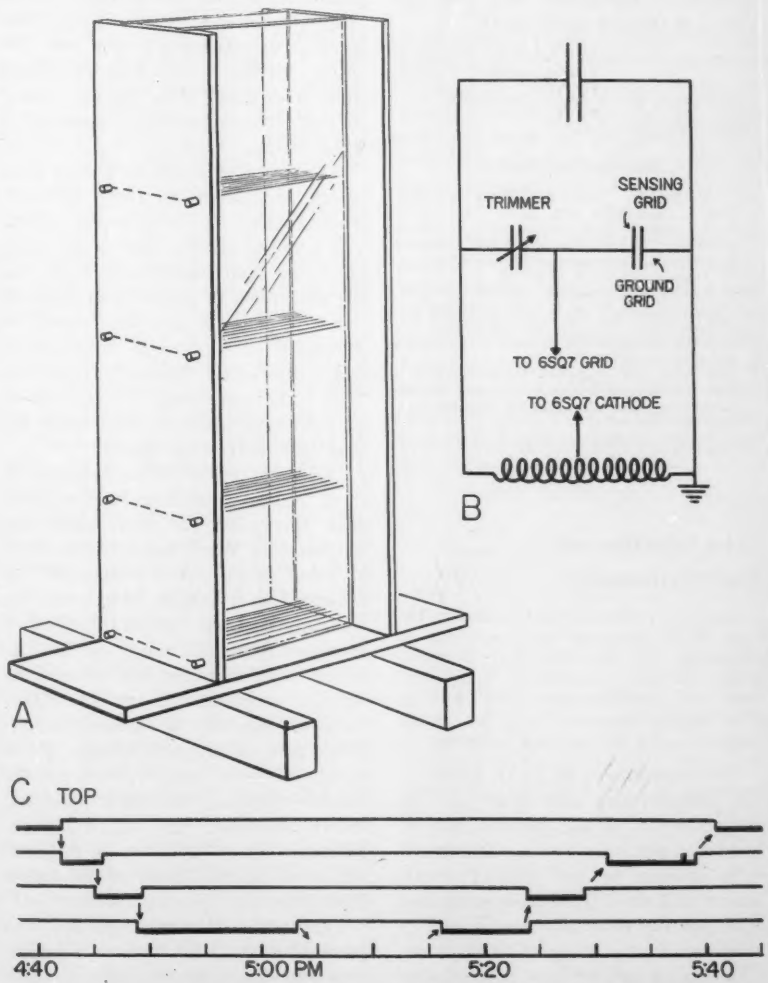

Fig. 1. *A*, Experimental enclosure (ground grids omitted). *B*, Simplified a-c circuitry of the Hartley oscillator. *C*, Esterline-Angus record of the movements of a 10-inch specimen of *Chionactis occipitalis* from near the surface of the sand to the bottom of the chamber (presumably below the bottom grid) and back in less than 1 hour. The on-signals of the recorder tracings are shown as heavy segments. Note that overlapping of on-signals occasioned by multiple detuning is most marked on the descent.

Recorded sorties at the surface are checked by inspection of the surface sand for tracks. Such tracks are smoothed so that subsequent sojourns at the surface can also be verified. It is interesting to note that smoothing surface sand does not disturb an animal resting within a fraction of an inch of the surface unless its body is actually touched.

Both *Chilomeniscus stramineus* and *Chionactis occipitalis* were often seen to rest near the surface with only an inch or so of the tail exposed. Similar behavior reported for *A. pulchra* (*2*) was not noted by us. Although its significance has not been established, a temperature-sensing function served by this behavior seems possible.

Future reports will deal with detailed records of movements and with the effects of thermal gradients (*6*).

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5. We are indebted to the Millard D. Shriver Co. of Rosemead, California, and Instruments Inc. of Tulsa, Oklahoma, for the loan of oscillators and other courtesies.
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20 July 1961

Color Induction and Hue Discrimination

Abstract. A very close relationship has been found between hue discrimination thresholds and the differences in wavelength necessary to produce "full color" from two monochromatic light sources. This finding suggests a need for certain research in the area of color induction.

The experiments of E. H. Land (*1*, *2*) demonstrating that many of the natural colors of the spectrum can be produced with only two monochromatic light sources, or one monochromatic source and white light, have stimulated much spirited discussion among persons interested in the study of color vision. The opinion held by most psychologists is that the effects produced by Land are not new and can be explained by mechanisms known to color theorists for many years. G. L. Walls (*3*) has pointed out that most of the colors which Land produced can be explained by simultaneous color contrast or spatial induction—phenomena which have been familiar to psychologists for over 100 years. Viewed in this light, the Land effect loses much of its dramatic appeal as a possible source of a new theory of color vision.

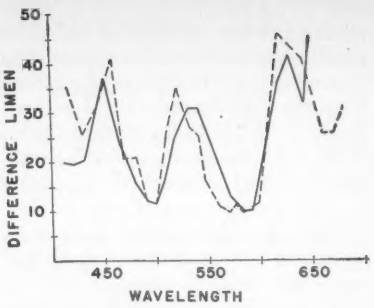

Fig. 1. Wavelength differences between projection primaries for a good effect (Land), dashed line, and hue discrimination thresholds (× 10) (Hecht), solid line. The units of both axes are millimicrons.

There is one aspect of Land's work which does seem surprising to many psychologists: The wavelength separation between the two sources of monochromatic light which is necessary for the perception of colors other than the colors projected is surprisingly small. A difference in wavelength of about 45 mμ seems to be sufficient to produce "full color" regardless of the position on the visible spectrum from which the two light sources are selected.

I decided to see what relationship these spectral separations have to difference thresholds for wavelength discriminations. When two monochromatic lights of the same wavelength are presented to a human subject and the wavelength of one light is increased or decreased until the subject is able to discern a difference in hue between the lights, it is found that the amount of variation necessary is different for different points along the spectrum. These thresholds have been reproduced by Hecht (*4*) (using the data of Steindler, 1906) and show that the maximum difference limen is about 4 mμ and occurs in the red region of the visible spectrum.

Land (*2*) has given in his Fig. 3 a graph showing the color arrays obtainable with various combinations of wavelengths used in projecting two superimposed images on a screen. From this graph one can obtain the minimal separation of longer and shorter wavelengths required in different spectral regions for a greater or lesser approach to "full color" in the projected picture.

The solid line in Fig. 1 shows the hue discrimination thresholds as reproduced by Hecht. These thresholds have been multiplied by 10. The dashed line represents the wavelength differences between projection primaries for a good effect as derived from Land's graph. These values are not multiplied by a constant.

One can see that there is a striking similarity between these two functions. The most obvious conclusion that can be drawn from this concomitant variation is that the production of "full color" from two monochromatic lights is dependent upon the existence of a sizable subjective difference in color between the two projection primaries. Thus, the three maxima of both functions correspond to regions of the spectrum in which a relatively large difference in wavelength is necessary to produce a subjective color difference. The interesting point to be made here is that it would appear from the graph that the wavelength separation necessary for "full-color" perception is some ten times as great as that necessary for a noticeable difference in hue.

Suppose that an annulus or ring of monochromatic light were projected upon a screen and that a second projector cast a spot of light of the same wavelength which filled the center of the annulus. If the wavelength of the surrounding annulus were varied, a point would be reached at which there would occur a noticeable change in the hue of the spot, despite the fact that the wavelength of the spot remained constant. On the basis of Walls's explanation of Land's findings and the relationship between the functions plotted in Fig. 1, one might expect that the change in wavelength of the annulus required to produce a change in the spot would be ten times that change required to cause a subjective difference in the hues of the spot and annulus (with each viewed through a mask which would prevent spatial induction).

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31 July 1961

Phototropism in Conidiobolus, Some Preliminary Observations

Abstract. The action spectrum for phototropism of *Conidiobolus* conidiophores was determined crudely with glass filters and by projecting a spectrum on cultures of the fungus. The active wavelengths (about 400 to 650 mμ) corresponded in general with those absorbed by extracts containing a pigment with an absorption spectrum characteristic of a porphyrin.

It is well known that conidiophores of *Conidiobolus*, a member of the phycomycetous order Entomophthorales, grow toward a source of light. It is the purpose of this paper to report the results of a preliminary investigation of phototropism in this fungus.

The strain of *Conidiobolus* used for these trials was isolated by the canopy plate technique of Drechsler (*1*) from decaying leaves of *Sequoia sempervirens* Endl. The fungus is similar to one studied by Morrow (*2*) and resembles *Conidiobolus villosus* Martin in that it produces villose conidia under some conditions. It was grown on potato-dextrose agar or on a medium which contained 0.5 percent asparagine, 2.0 percent glucose, and salts. When cultures were illuminated unilaterally by an incandescent lamp, positive phototropism was indicated by an accumulation of conidia and young mycelia at the side of the culture nearest the light.

In order to determine what wavelengths of light are capable of eliciting a phototropic response, Corning glass filters were interposed between the lamp and the cultures. Phototropism was induced not only by light passed through a blue filter (5543), but also by light passed through sharp cut filters which transmit less than 0.5 percent of wavelengths shorter than 471 and 599 mμ. The fact that light from a red photographic safelight was effective even when passed through a red filter (2408) is additional evidence that this species of *Conidiobolus* is capable of responding to orange or red light as well as to blue light. That the response is not to heat or to far-red light is indicated by the fact that no response was shown by cultures which were illuminated by light from a photographic safelight passed through a far-red filter (5840).

In an attempt to obtain further information on the effective wavelengths of light, a spectrum was projected on a culture of *Conidiobolus*. Light from an incandescent lamp was focused through a slit on a collimating lens, dispersed by a 60° prism, and directed on the fungus by a second lens. The apparatus was calibrated by placing a fluorescent lamp in front of the slit and marking the emission lines of mercury. The fungus was grown in a transparent plastic box with a glass plate in the bottom and an agar slant partially covering the plate. The slant was inoculated by streaking conidia near its edge in a line at right angles to the direction of the light, so that conidia discharged toward the light collected on the glass plate. After 4 or 5 days, the results were recorded by placing the plate in a photographic enlarger and projecting the image on sensitized paper.

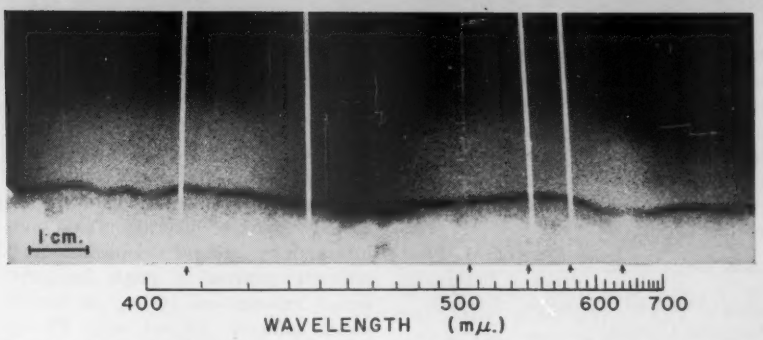

Fig. 1. Action spectrum for phototropism of *Conidiobolus* obtained by projecting spectrum on culture. Degree of positive response is indicated by density of conidia (white) on glass. Lines show approximate positions of emission lines of mercury. Arrows show positions of peaks of absorption spectrum shown in Fig. 2.

The results indicated that the fungus responds to wavelengths as long as about 650 mμ (Fig. 1). Conidia accumulated most densely on the glass plate opposite those portions of the growth illuminated by violet (about 400 mμ) and green-red light (about 490 to 650 mμ).

In order to discover whether *Conidiobolus* contains a pigment which absorbs light of wavelengths similar to those effective in inducing phototropism, absorption spectra of extracts were determined. The fungus was grown in Roux bottles containing 100 ml of liquid asparagine-glucose medium. Mats of mycelium from 12-day-old cultures were ground with acetone. The acetone was extracted with petroleum ether, and after partition, the petroleum ether layer was discarded. The fact that the petroleum ether extract was colorless indicates that this species of *Conidiobolus* does not contain carotinoids in appreciable quantities. The yellowish acetone layer was clarified by centrifugation, and its absorption spectrum was determined with a Bausch and Lomb recording spectrophotometer.

As shown in Fig. 2, the absorption spectrum is of a type characteristic of certain porphyrins (*3*) with a strong absorption peak in the violet and four peaks in the green, yellow, and orange portions of the spectrum. Dioxane extracts showed peaks at 412, 506, 543, 580, and 630 mμ.

The results of these preliminary experiments indicate that *Conidiobolus*—unlike higher plants and such fungi as *Phycomyces* and *Pilobolus* (*4*)—is capable of responding phototropically to green, yellow, and orange light as well as to violet and blue light. Further, this fungus contains a porphyrin pigment which absorbs light in these same general portions of the visible spec-

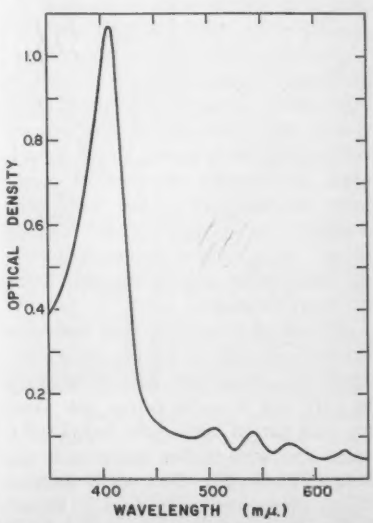

Fig. 2. Absorption spectrum of acetone extract of *Conidiobolus*.

trum. Since the wavelengths of light absorbed by the pigment are similar to those effective in phototropism, it is possible that the porphyrin is the photosensitive pigment; however, further investigation will be required to determine whether this interpretation is correct (*5*).

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26 June 1961

Antigen Disappearance in Hibernating Ground Squirrels

Abstract. The rate of antigen disappearance was studied in hibernating ground squirrels (*Citellus tridecemlineatus*) injected with I^{131}-labeled bovine serum albumin. There was no detectable disappearance of antigen during 14 days of hibernation. The induction period, however, ended 5 days after arousal as compared to a 7-day induction period in nonhibernating ground squirrels.

The resistance of hibernating animals to infection has been studied by a number of workers (*1*). It would appear that resistance to infection is increased with entry into hibernation. There is no evidence to suggest that increased resistance to infection is other than a nonspecific effect associated with physiological changes accompanying this process. To our knowledge, the immune response of mammals in hibernation has not been studied. The present study is concerned with antigen disappearance in the hibernating ground squirrel, *Citellus tridecemlineatus* (*2*).

The ground squirrels were collected in northern Illinois during September 1960 and were maintained in a room at 23°C for 6 weeks before use. During this period they were individually caged and allowed free access to Rockland Guinea Pig Diet with supplements of carrots twice weekly. Hibernation was induced by placing the animals, individually caged in a deep bed of wood shavings without food or water, in a room at 5°C and 50-percent relative humidity. They were checked twice daily to determine their state of hibernation.

We followed the disappearance of I^{131}-labeled bovine serum albumin from the circulation of hibernating and nonhibernating ground squirrels. All squirrels received a single intraperitoneal injection of 10 mg of bovine serum albumin labeled with I^{131} by the method of Talmage *et al.* (*3*). Serum from ground squirrels was iodinated and injected by the same procedure.

Blood samples from the tail were collected on tared filter paper, weighed, and counted in a well-type scintillation counter. Counts were corrected for background, disintegration, and weight of sample, converted to percentage of the activity of the sample taken 1 day after antigen injection, and plotted on a semilogarithmic scale. The rate of antigen disappearance was in three phases, as indicated by marked changes in the slope of the plot. These three phases were, in the terminology of Dixon *et al.* (*4*), (i) the equilibration phase, (ii) the nonimmune elimination phase, and (iii) the immune disappearance phase which marks the appearance of antibody.

In Fig. 1 the mean slopes are plotted for each phase of antigen disappearance in four treatment groups. The mean slope for the period of equilibration is an average of the slopes of that phase for the individuals in the group. The mean slopes for the nonimmune elimination and the immune phases were obtained by means of the same method.

Group A was composed of 14 squirrels that remained at room temperature after antigen was injected. The first blood sample was taken 1 day after the injection, four during the next 6 days, and three in the course of the next 5 days. The period of equilibration was less than 1 day in ten animals and as long as 3.5 days in four animals where the mean half-disappearance time was 2.3 days. During the nonimmune elimination phase that followed, the rate of antigen disappearance slowed so that the antigen level decreased by half in 5.4 days. On the seventh day after antigen injection the half-disappearance time decreased to 1.5 days. This increase in rate of disappearance is considered to mark the end of the induction period and the beginning of the immune phase wherein the appearance of antibody in the circulation is followed by rapid removal of the circulating antigen-antibody complexes. This sequence is qualitatively similar to that observed by Dixon *et al.* (*4*) in rabbits.

Group B was composed of 11 animals that were placed in the cold room immediately after antigen injection. They all entered hibernation within a day. During the 2-week hibernation period only four samples were taken; after arousal the sampling schedule was the same as for group A. There was little or no disappearance of antigen during the period of hibernation. After arousal, the half-disappearance time became 4.4 days, which was not statistically different

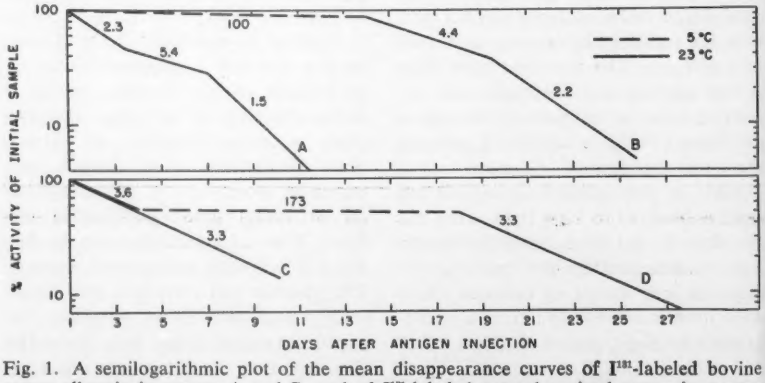

Fig. 1. A semilogarithmic plot of the mean disappearance curves of I^{131}-labeled bovine serum albumin in groups A and B, and of I^{131}-labeled ground squirrel serum in groups C and D. After injection of labeled material on day 0: (*A*) 14 animals maintained at 23°C; (*B*) 11 animals maintained at 5°C for 14 days in hibernation followed by a return to 23°C; (*C*) 4 animals maintained at 23°C; (*D*) 5 animals at 23°C for 4 days, then in hibernation at 5°C for 14 days followed by a return to 23°C. The numbers associated with each phase of the plot show the half-disappearance time in days.

from that of the nonimmune elimination phase in group A (5.4 days, $p > .20$). The induction period ended after 5 days when the half-disappearance time decreased to 2.2 days. The statistical significance of the difference between the immune disappearance times for groups A (1.5 days) and B (2.2 days) was equivocal ($p = .05$), but the difference between the induction period for group A (7 days) and the posthibernation induction period of group B (5 days) was significant ($p < .001$).

To determine whether the rate of disappearance of the antigen upon awakening from hibernation was comparable to the nonimmune disappearance rate or was actually the result of physiological processes peculiar to arousal, we studied the disappearance rate of labeled squirrel serum.

In four squirrels (group C) injected with labeled serum, the half-disappearance time was 3.3 days. In five squirrels treated similarly (group D) that entered hibernation 4 days after serum injection, the half-disappearance time upon arousal from 14 days of hibernation was 3.3 days. This was almost identical with the half-disappearance time of 3.6 days for the same animals during the 4 days before hibernation and for the group C animals that did not hibernate. In group D, as in group B, there was little or no disappearance of the labeled material during hibernation. Therefore, it is safe to assume that the disappearance rate of antigen in squirrels after arousal is the reflection of a physiological state (measured by antigen disappearance) comparable with that of the nonhibernating ground squirrels.

Although there is little or no disappearance of homologous or heterologous proteins from the circulation of hibernating ground squirrels, the induction period ends 5, not 7, days after arousal (group B, Fig. 1). Since the normal induction period is 7 days (group A, Fig. 1), it would appear that some of the events that occurred during the induction period transpired while the ground squirrels were hibernating. Work is in progress to determine whether the whole or only part of the induction period can be passed in hibernation.

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18 May 1961

Development of Needle Blight Symptoms on Rooted Cuttings from Diseased White Pine Trees

Abstract. A method of rooting cuttings from white pine trees is described. Approximately equal numbers of cuttings from diseased and healthy trees were rooted by this method. After the rooted cuttings were planted in the field, they were closely watched for root growth and the development of foliar injuries.

The disease, needle blight of eastern white pine (*Pinus strobus L.*), is characterized by an orange-red discoloration of the distal portions of current-year needles. For more than 50 years it was believed that the disease affected the tips of needles first, and that this was followed by a progressive dieback. To the contrary, it was recently discovered (*1*) that the injury began in semimature leaf tissues and then spread distally to more mature tissues. Based on data with respect to the nature and occurrence of the foliar symptoms, the hypothesis was set forth that needle blight is heritable (*1*).

Support for this theory would ensue if shoots removed from diseased or healthy trees and induced to root should produce phenotypic reactions similar to their parents when grown under similar environmental conditions. The question also arose whether cuttings from needle-blighted trees could be rooted, since diseased trees possibly lack food reserves because of reduced needle and shoot growth (*2*) and death of distal ends of needles.

Cuttings were taken from trees with histories either of disease recurrence or of freedom from blighting. The selected trees were 10 to 13 years old, which is considered fairly old by forest geneticists for obtaining high percentages of successfully rooted cuttings (*3*). Most conifer cutting experiments involve seedlings 3 to 6 years old. Trees this young, however, usually do not possess sufficient shoots to provide large enough clones for further experimentation.

Twenty-five cuttings were removed from each of four trees (two diseased and two healthy) in early September 1958, after shoot growth had ceased and buds had fully developed. Lateral shoots, 3 to 5 inches long, the full length of the current growth, were pulled from the trees. The basal fascicles were not removed. The "heels" were trimmed with a sharp knife, and the bases of the cuttings were dipped in 0.2 percent indolebutyric acid in talcum powder. The cuttings were placed immediately into pots 12 inches in diameter and 8 inches high. The medium used was Perlite (*4*), a chemically inert substance with good drainage and aeration properties. About one-third of the length of the cuttings was inserted into the firmed, moistened medium, and the cuttings were spaced about 1½ inches apart with 2 inches between rows. The 25 cuttings from each tree were placed in a separate pot. Wire hoops placed in the pots formed supports for thin polyethylene plastic covers. These covers were removed once a day, and the cuttings were sprayed with water until a fine film covered the needles. The covers helped maintain high humidities about the cuttings and also allowed an exchange of gases. The pots were kept at room temperature on a bench adjacent to

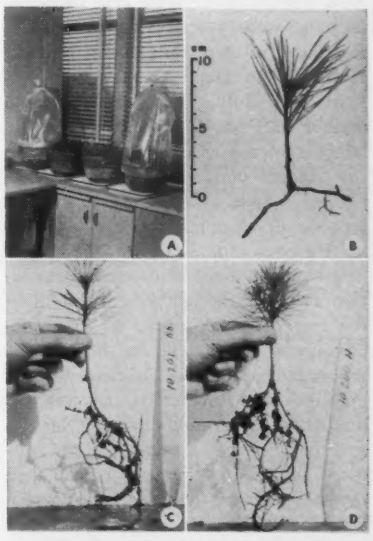

Fig. 1. Rooting of white pine cuttings: *A*, cuttings in pots showing wire hoops and polyethylene covers; *B*, cutting from a needle-blighted tree that rooted within 8 months; *C*, rooted cutting from a diseased tree 1 year after striking roots; *D*, rooted cutting from a healthy tree 1 year after striking roots.

windows with venetian blinds that could be adjusted to reduce the sunlight when necessary (Fig. 1*A*). No nutrients were added to the media before or during the rooting procedure. Once a week, the pots were immersed in tap water for 10 minutes, and then drained. The cuttings were sprayed with pesticides about once a month to combat fungi and insects.

Sample cuttings were removed periodically and examined for any evidence of rooting. The first cutting to strike roots was observed 7 weeks after potting. Mortality of both diseased and healthy cuttings was high in the first 4 months. Twenty-one cuttings rooted within 8 months (Fig. 1*B*), and eight more rooted within 12 months. From the original 100 cuttings, 29 rooted, of which 14 were from diseased and 15 from healthy trees.

The rooted cuttings were planted individually in pots, 5 inches in diameter, containing a 1:1 mixture of Perlite and surface soil from a hardwood stand. The cuttings were kept moist and partially shaded in a greenhouse. In late September 1959, nine of the rooted cuttings (six from a diseased tree and three from a healthy tree) were lined out in a nursery, located approximately 3 miles from the site of the parent trees. The cuttings were planted in the same type of media in pots, were placed side by side in the nursery, and thus were growing essentially in identical sites.

In late July 1960, the diseased mother tree developed initial needle blight symptoms. Examination of the six rooted cuttings from this tree, planted 3 miles away, revealed a simultaneous development of needle blight on the new foliage, with the injury originating in tissue of the same maturation as in the mother tree. In addition, the rate of distal spread of foliar necrosis was comparable in the cuttings and in the parent tree. The three healthy cuttings were unaffected, as was the mother tree. Examination of the extent of the root systems of the diseased and healthy cuttings 1 year after they struck roots revealed no apparent differences between the two (Fig. 1, *C–D*).

From the above observations it may be concluded: (i) that the excessive mortality of main root tips which has been found to occur in needle-blighted trees (*5*) probably is a consequence of the disease and is not primarily associated with the cause of needle breakdown; and (ii) that symptom development which occurred simultaneously in the same local area on rooted cuttings and their diseased parent tree is further evidence strengthening the hypothesis that susceptibility to the unfavorable conditions which contribute to needle blight is inherent in the individual (*6*).

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10 April 1961

Transmembrane Action Potentials from Smooth Muscle in Turtle Arteries and Veins

Abstract. Transmembrane potential and active tension were measured in isolated segments of turtle aorta and inferior vena cava. Changes in tension were associated with action potentials, but the potentials had a different pattern in the two tissues. When the frequency of the action potentials increased, the contractions summated, resulting in a steadily maintained contraction.

The activity of smooth muscle in blood vessels has usually been estimated indirectly by measuring the diameter of intact vessels, the tension in isolated strips of vessel, the compliance in the vessel wall, or the resistance to flow. The results of such measurements have often been difficult to interpret because it was impossible to determine the relative contributions of active changes in the muscle and passive changes due to the physical properties of the wall.

A more direct way of assessing muscle activity in blood vessels would have many advantages. One method would be to measure the electrical changes accompanying activity in single cells. Unfortunately, muscle cells in blood vessels are generally very small and are usually surrounded by considerable amounts of fibrous and elastic tissue, especially in larger vessels. Consequently, the impalement of these cells with microelectrodes and the measurement of their membrane potential is very difficult. Turtle arteries and veins contain relatively little fibrous and elastic tissue, which makes the impalement of their muscle cells somewhat easier. The present report describes some relationships between changes in tension and membrane potential in the smooth muscle of these vessels.

Excised segments of the abdominal aorta and the inferior vena cava were cut open lengthwise and mounted in an organ bath filled with frog Ringer's solution at 24°C. The transverse tension exerted by the opened segment was measured with an RCA mechanoelectronic transducer (No. 5734). Single muscle cells were impaled through the intimal surface with "floating" microelectrodes (*1*).

The time courses of membrane potential and contractile tension during rhythmic activity in aorta are shown in Fig. 1. In this experiment the resting potential was about 35 mv. It can be seen that the increase in tension was just preceded by a single heartlike action potential, which consisted of a

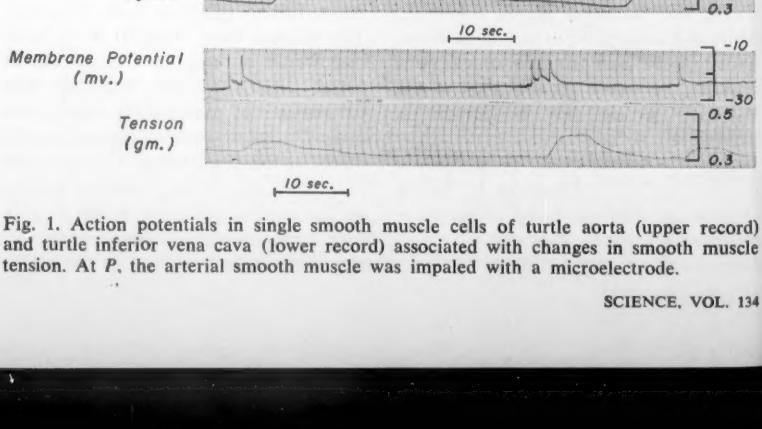

Fig. 1. Action potentials in single smooth muscle cells of turtle aorta (upper record) and turtle inferior vena cava (lower record) associated with changes in smooth muscle tension. At *P*, the arterial smooth muscle was impaled with a microelectrode.

rapid spike of depolarization followed by a long plateau. The spike, but not the plateau, overshot the zero potential level. In this example the membrane repolarized within about 12 seconds, but some action potentials lasted up to 40 seconds. Often, a small prepotential was seen.

Although the shape of the action potential resembles somewhat that of ventricular myocardium, the two types of muscle differ in other respects. The resting potential and the action potential are higher in heart than in arterial muscle. A single contraction lasts much longer in arterial (30 to 200 sec) than in ventricular muscle (1 to 3 sec). In heart muscle the cell membrane remains depolarized practically throughout the contraction, whereas in arterial muscle the membrane usually repolarizes before maximum tension is reached. The relatively shorter refractory period in the artery permitted summation of contractions when the rate of firing was increased, resulting in steadily maintained contractions. As in cardiac muscle an increase in the frequency of the action potentials decreased their duration.

A different pattern was seen in the veins. Some spontaneous contractions occurred, but they were less rhythmic and more variable in strength than the arterial contractions. Each contraction was preceded by one or more action potentials (Fig. 1). These consisted of a spike of depolarization. However, repolarization was much more rapid than in the arteries, so that the plateau following the spike was often barely perceptible. Action potentials were often followed by a period of hyperpolarization. When trains of spikes followed one another closely, the contractions summated to produce a fairly steady contraction.

The differences between the action potentials seen in the artery and the vein emphasize the danger of considering the configuration in one type of vessel as representative of that in all vascular smooth muscle. However, spikelike action potentials were recorded in the inferior vena cava of the guinea pig, and long action potentials similar to those in turtle arteries were recorded with difficulty in the aorta of the frog (2).

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10 April 1961

Repression of Ornithine Transcarbamylase Protein Formation by Arginine

Abstract. Arginine-repressed cells of *Escherichia coli* W do not form a protein immunologically related to ornithine transcarbamylase. This was determined by lack of cross-reactivity of repressed cell extracts with rabbit antisera prepared against purified ornithine transcarbamylase. The results indicate that arginine acts by blocking the synthesis of the entire enzyme-protein.

Escherichia coli W cells grown in the presence of arginine contain only negligible amounts of ornithine transcarbamylase (OTC), an enzyme in the biosynthetic pathway leading to arginine formation. It has been shown (*1*) that arginine acts as a repressor of the synthesis of OTC activity in these cells, and recent evidence (*2*) suggests that perhaps ornithine competes with arginine for the site of repressor action. When arginine is removed from the growth medium, a 100-fold increase in OTC activity occurs in *E. coli* W; this increase in activity has been correlated with new protein synthesis (*3*).

In order to investigate the function of arginine in the regulation of ornithine transcarbamylase synthesis, it was first necessary to determine whether arginine blocks the synthesis of the entire OTC-protein or, alternatively, changes the configuration of the active site or prevents synthesis of a small portion of the molecule. If these cells form an enzymatically inactive OTC-like protein in the presence of arginine, this altered protein should be detectable by immunological techniques. With the use of specific antisera to the inducible enzyme, β-galactosidase, it has been shown (*4*) that uninduced cells contain no antigenically active protein related to this enzyme. Experiments described in the present report suggest that in like manner arginine represses the formation of the entire OTC-protein.

By use of a 100-fold purified OTC preparation from *E. coli* W (*5*), an antiserum was prepared from rabbits according to the method of M. Cohn (*6*). One milligram of purified OTC emulsified with Freund's adjuvant containing mycobacterium was injected into the rabbits intramuscularly under the scapula. The injection was repeated weekly for 30 days, and after two additional weeks the rabbits were bled. The serum obtained from rabbit blood was clarified by centrifugation, and the globulin fraction was collected by precipitation with ammonium sulfate at 33 percent saturation. The precipitation of a 100-fold purified OTC antigen with the prepared antisera is shown in Fig. 1. At the equivalence point about 0.24 mg or 212 units of OTC are precipitated per milligram of antisera protein in the precipitate. It was possible to demonstrate 30 percent of the original OTC activity in the washed precipitate by running it gently through a thin-nosed pipette. However, it was not possible to release the enzyme

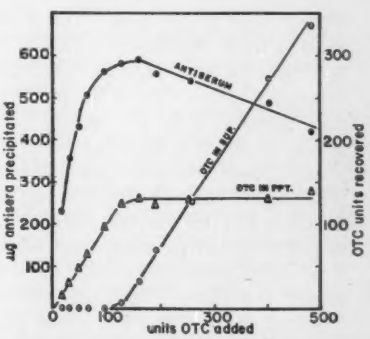

Fig. 1. Relationship between amount of rabbit antiserum precipitated and amount of purified ornithine transcarbamylase added. Precipitation reactions were carried out as follows: 0.1 ml of rabbit antiserum prepared as explained in the text; increasing amounts of purified OTC (specific activity = 873 μmole of citrulline produced per minute per milligram of protein) were added; final volume of each tube to 1.7 ml with 0.15*M* NaCl; incubated at 3°C for 3 days; centrifuged; precipitates washed three times in 0.15*M* NaCl. Curve •: micrograms of antiserum protein precipitated per tube calculated by subtracting the antigen precipitated from the total protein precipitated. At the point of maximum antiserum precipitation (590 μg), 129 units of OTC were precipitated. Curve o: units of OTC remaining in the supernatant determined as reported previously (*3*). Curve △: units of OTC in the precipitate calculated by subtraction of curve o from total OTC added. OTC activity was also demonstrated in the precipitates as discussed in the text.

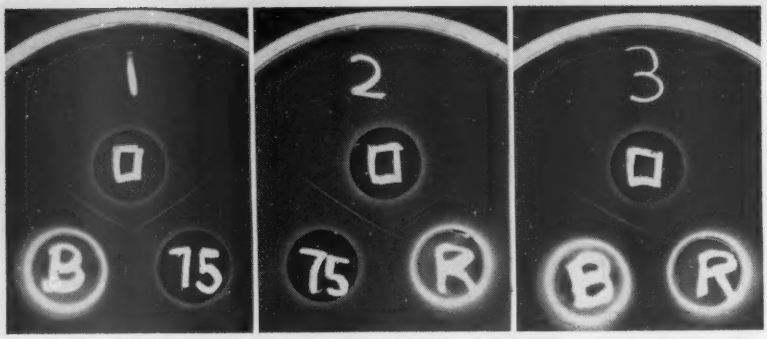

Fig. 2. Ouchterlony agar diffusion plates showing the reaction of anti-OTC with purified OTC, and extracts from arginine repressed and derepressed *E. coli* W cells. Well □: 0.18 mg of anti-OTC serum protein; Well 75: 28 μg of OTC containing 1040 units per milligram of protein [one unit of OTC activity equals 1 μmole of citrulline produced per minute at 37°C under the conditions of assay previously reported (*3*)]; Well B: 0.3 ml of crude extract of derepressed *E. coli* W cells containing 45.6 units of OTC and 3.1 mg of protein; Well R: 0.3 ml of a crude extract of repressed *E. coli* W cells containing 0.8 units of OTC and 3.1 mg of protein. The distance between wells was 14 mm. Plates were incubated for 6 days at 27°C, and contact prints were made. Duplicate plates were run in all experiments.

from the antibody by treatment with acetic acid at *p*H 5 or by ammonium sulfate fractionation.

Extracts from derepressed *E. coli* W cells with a high level of OTC and extracts from arginine-repressed *E. coli* W cells with low levels of OTC were compared on the basis of the precipitation reaction with the specific antiserum. Since the preparations of repressed cells demonstrated a small precipitation reaction which could not be accounted for on the basis of observed OTC activity alone, the Ouchterlony agar diffusion method was employed (*7*). With a 200-fold purified preparation of OTC, formation of a large distinct precipitation line was demonstrated along with two minor lines by this method.

Diffusion agar plates were then prepared with crude extracts of repressed and derepressed *E. coli* W, and purified OTC was opposed to the rabbit anti-OTC serum. Figure 2 illustrates contact prints of three diffusion plates obtained. On diffusion plate 1 (Fig. 2), the purified enzyme (Well 75) formed a definite reaction of identity with the crude extract of derepressed cells (Well B), both in the major heavy precipitation line (OTC) and in the minor lines due to contaminating proteins. On plate 2 the same amount of protein from a crude extract of arginine-repressed cells (Well R) formed no reaction of identity with respect to the major heavy line of purified OTC reacting to anti-OTC serum. The contact print of plate 3 shows the lack of identity of protein from repressed cells (with respect to the major line) when allowed to diffuse simultaneously with the extract from derepressed cells against the anti-OTC serum.

The evidence above strongly favors the hypothesis that arginine, or a repressor formed from arginine, blocks in some yet unknown way the formation of the entire OTC-protein molecule at the site of synthesis (presumably the ribosomes). However, it should be pointed out that the lack of a precipitation reaction or the absence of a displacement reaction as shown by Perrin *et al.* (*4*) does not eliminate the possibility of synthesis of at least part of the OTC molecule or β-galactosidase molecule, as the case may be, at the enzyme-forming site during repression (*8*).

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26 April 1961

Plumage in Lal Munia (Amandava amandava)

Abstract. An Indian ploceid finch, *Amandava amandava*, develops brilliant nuptial plumage in males during the breeding season. The females and males outside of the breeding season have modest brown hen plumages. The fact that castrates, whether originally of male or of female sex, assume nuptial plumages during the breeding season of the species indicates that plumage character is under the control of hypophyseal hormones and that hypophyses are passing through an activity cycle which is independent of presence or absence of gonads.

Plumage of African weaver finches is under hypophyseal control (*1*), specifically under luteinizing hormone (*2*), and this fact has been made use of in developing an assay for luteinizing and chorionic gonadotropic hormones (*3*). These finches are natives of Africa and are imported at great cost in the United States, where many laboratories are now maintaining them. As quite a few species of finches occur naturally in India (*4*, *5*), it was, therefore, decided to investigate their plumage control.

We have investigated some species of Indian finches and one of these, lal munia (*Amandava amandava*), which is a very beautiful bird (family, Ploceidae), has yielded encouraging results. Males are brilliantly colored and have vermillion red bills during the nuptial phase. The head and upper plumage are crimson colored. The tail is black and the outer feathers are tipped with white. From chin to breast it is deep crimson, sparsely spotted with white. Females are dull brownish with wing coverts and inner secondaries tipped white and upper tail coverts crimson with small terminal white specks. The tail is brownish black, the chin yellowish white, while the throat and upper breast are grey. Abdomen and under tail coverts are light brownish white (*5*). Males in eclipse resemble females.

A number of birds of both sexes were castrated during the fall, and their feathers were subsequently examined every month. During March and April, males, castrated males, and castrated females regenerated male nuptial plumage. This coincides with the progressive phase of their sexual cycle (*6*). Intact females maintain hen plumage all year round.

The appearance of nuptial plumages in normal males and castrates of both sexes suggests that cock plumage is gonad independent in this species and that the ovarian hormone suppresses

its manifestation in normal females. This is just as it is in the African weaver finches, and so the plumage may reasonably be expected to be under the control of some hypophyseal factor. If this is proved, *Amandava* could also be used for assay purposes as African finches are now.

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22 May 1961

Puromycin-Induced Changes in Uredospores of Puccinia sorghi Schw.

Abstract. Puromycin stimulates substrate consumption and initiates an accumulation of amino acids in uredospores of the corn rust fungus. The results indicate that under suitable conditions uredospores should be able to synthesize appreciable quantities of amino acids, but must be stimulated to do so.

Uredospores of the rust fungi synthesize amino acids and other metabolic intermediates very slowly compared to the common saprophytes (*1*). Although many intermediates will eventually become radioactive when uredospores are stirred with radioactive substrates, the amount of radioactivity is small (*1–3*). Since germination of saprophytic fungi is accompanied by the synthesis of proteins and polynucleotides while that of the rusts is not (*2*), inducing uredospores to provide sufficient intermediates for the synthesis of these macromolecules may prove to be a partial solution of growth failure in these obligate parasites. Consequently, a search was initiated for a compound which would stimulate uredospores to consume carbon compounds at a more rapid pace. Carcinogens, like 3,4-benzpyrene, structural analogs, like *p*-fluorophenylalanine, and antibiotics, like chloromycetin, were tested, but puromycin alone induced an accumulation of radioactive amino acids in germinating corn rust uredospores.

Table 1. The effect of puromycin on acetate utilization by corn rust uredospores. The medium included 0.1 g glucose, 5 μc sodium acetate-2-C^{14} (0.21 mg), and 50 mg spores suspended in 200 ml of 0.01-percent vol/vol aqueous Tween 20. The spores were exposed to the substrate on a shaker for 6 hours. The results are counts per minute per milligram of protein N.

Characteristic	Puromycin (ppm)	
	0	80
Fraction		
Amino acids	77,100	295,200
Organic acids	211,000	184,500
Sugars	193,100	310,700
Nucleic acids	55,700	236,700
Protein	65,500	161,200
Residue	2,200	5,400
Total	604,600	1,193,700
Protein N	0.42 mg	0.66 mg
Germination	94%	90%

The spores were germinated as described previously (*4*). A complete description of methods employed for extraction and analysis of components appears elsewhere (*1*). The results of a typical experiment are presented in Table 1. In the presence of puromycin the total acetate consumption was nearly doubled, radioactivity of the amino acid fraction was increased approximately fourfold, while that of the organic acid fraction decreased. The specific activity of the protein and nucleic acid fractions increased nearly threefold and fourfold, respectively. Radioactivity in the amino acid fraction increased logarithmically with increasing puromycin concentration up to 80 ppm. The specific activities of the free and protein-bound amino acids increased in approximately the same order of magnitude as did the total activities of their respective fractions. The source of nitrogen for the increased synthesis of these amino acids is unknown. However, there was but little net synthesis of proteins; the protein nitrogen increased with the increasing concentration of puromycin until about 20 ppm puromycin were added, after which no further increase was observed.

Puromycin is normally considered to be an inhibitor of protein synthesis (*5*), and it was readily found to inhibit the incorporation of radioactive L-leucine, L-glutamate, and D-glucose into the protein fraction of the uredospores (Table 2). Despite such inhibition, total consumption of these materials and their rates of conversion to free amino acids were augmented just as when acetate was employed. It was therefore interesting to study the effect of exposing the spores to puromycin, washing out as much of it as would come out in two washings, and then shaking the uredospores in the presence of L-leucine-U-C^{14}. After pretreatment for 1 hour with puromycin, the spores incorporated radioactivity from leucine and from acetate into the protein fractions more than twice as fast as spores pretreated with water.

Table 2. The effect of 80 ppm of puromycin on substrate utilization by corn rust uredospores under the same conditions as described in Table 1. The values show the specific activity in the protein as percent of the control.

Radioactive compound used in substrate	Puromycin present in medium	Puromycin pretreatment
L-leucine-C^{14} (2 μc)	64	203
L-glutamate-1-C^{14} (2 μc)	54	
Glucose-U-C^{14} (5 μc)	48	
Sodium acetate-2-C^{14} (5 μc)	550	230

It seems clear that regardless of the cause of the changes occurring in the presence of puromycin, the spores do have a large capacity at least for amino acid synthesis, and under the proper conditions can respond to the environment with a vigorous consumption of substrate materials. The results after pretreatment of the uredospores with puromycin suggest that the uredospore normally has the means for an adequate synthesis of materials required for growth, but this capacity is partially suppressed under the usual environmental conditions. Puromycin thus appears to overcome partially the suspected inhibition.

Yarmolinsky and De La Haba have pointed out the analogy between the structure of puromycin and short-chain nucleic acids (*5*). Using these findings as a guide, we shall investigate the effect of soluble nucleic acids on rust uredospores (*6*).

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References and Notes

1. R. C. Staples, H. P. Burchfield, J. G. Baker, *Contribs. Boyce Thompson Inst.* **21**, 97 (1961).
2. R. Kasting, A. J. McGinnis, W. C. Broadfoot, *Nature* **184**, 1943 (1959).
3. R. C. Staples and L. H. Weinstein, *Contribs. Boyce Thompson Inst.* **20**, 71 (1959).
4. R. Syamananda and R. C. Staples, *Phytopathology*, in press.
5. M. B. Yarmolinsky and G. L. De La Haba, *Proc. Natl. Acad. Sci. U.S.* **45**, 1721 (1959).
6. This work was supported in part by a grant from the Rockefeller Foundation.

5 June 1961

Diurnal Periodicity of Luminescence in Three Basidiomycetes

Abstract. Evidence is presented showing that intensity of light emission in dikaryotic cultures of *Panus stipticus, Armillaria mellea,* and *Mycena polygramma* follows a diurnal pattern. The lowest values appear between 6 and 9 A.M. and the peak intensities occur between 6 and 9 P.M. This pattern is consistent regardless of whether the cultures are grown in total darkness, under constant illumination, or exposed to a normal day-night cycle.

The light emission of luminous fungi and bacteria, unlike that of animals, is continuous night and day and independent of stimulation, either internal or external (*1*). The work of Hastings (*2, 3*) on the biological "clock" *Gonyaulax* led me to study with advanced photometric techniques whether there was a diurnal rhythm of luminescence intensity in the following fungi: *Armillaria mellea, A. fusipes, Clitocybe illudens, Mycena galopus, M. polygramma, Panus stipticus,* and *Omphalia flavida.*

Armillaria mellea, Mycena polygramma, and *Panus stipticus* showed definite evidence of a constant endogenous diurnal periodicity of light emission intensity. The other species evidenced no such recognizable pattern.

Fourteen-day-old dikaryotic mycelial cultures, maintained in the dark at 22°C on 10-percent bread crumb agar, were used throughout most of this study after determination that cultures grown in total darkness give off about a 10-percent brighter light and are easier to maintain. Data were also obtained on cultures originally maintained under constant illumination and cultures under a 12 hour–12 hour dark-light condition, and since the results were identical to those of cultures started in total darkness the latter were used.

All measurements were made in a light-tight chamber by using a photomultiplier tube suspended and centered 4 cm above the level of the agar in Petri dishes, so as to record the light emission of cultures up to 9 cm in diameter. Values were obtained at 3-hour intervals except at the time of highest and lowest intensities, when readings were taken 30 minutes apart to determine the low and high points.

Fourteen-day-old cultures were approximately 4 cm in diameter, and in the five subsequent days total area of the colonies averaged 9 cm in diameter. Cultures between 14 and 21 days old exhibit the highest light intensities. No correlation appears to exist between total colony size and light emission intensity, since the central portion gets dimmer in time.

For all samples (Fig. 1) the highest intensities appeared between 6 and 9 P.M. (zonal sun time) with the peaks usually arriving at 7 P.M. and maintained for an hour or longer. The lowest levels were reached between 6 and 9 A.M., most frequently at 6:30 A.M., and sometimes maintained for 2 hours or more. This rhythm was detectable (bottom curve, Fig. 1) as early as 48 hours after inoculation, and is maintained in detectable intensities for as long as 7 weeks until extinction is reached because of lack of nutrients and accumulation of by-products.

There was also no apparent correlation between peaks of light intensity and accelerated cell divisions as determined by the increase of the total colony area at different times of day. This independence of the luminescence rhythm from the growth rhythm has also been found in *Gonyaulax* (*3*).

The rises and falls in light intensity during any 24-hour period were as high as 35 percent. Yet this substantial range of daily light emission has escaped notice, because it cannot be detected visually by the dark-adapted eye, and also, probably, because of lack of sensitive photomultipliers and short-term observations. Further studies are in progress to determine the effects of a number of external factors in varying this diurnal rhythm.

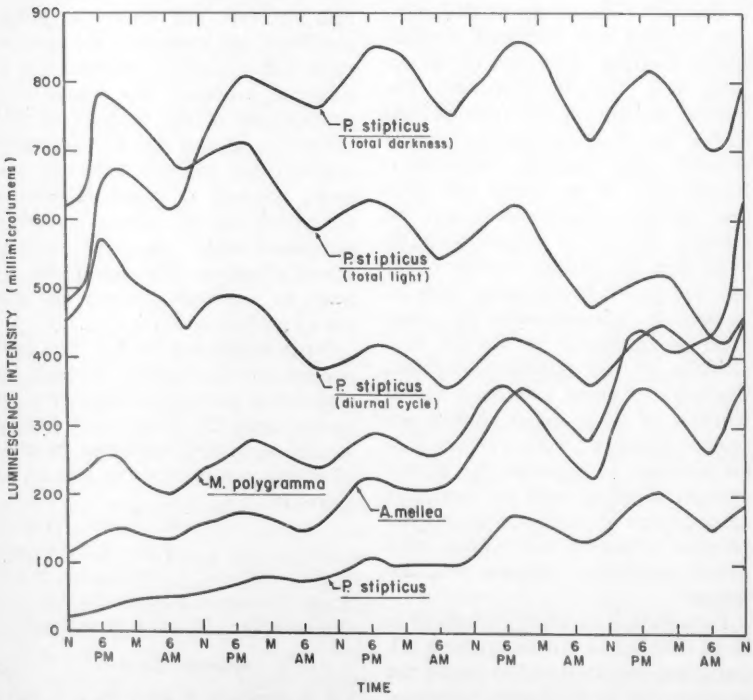

Fig. 1. Typical light intensity curves of 14-day-old cultures of *P. stipticus* kept in total darkness prior to the experiment (except bottom one, for which values were recorded 24 hours after inoculation). The curves for *A. mellea* and *M. polygramma* represent cultures kept in the dark throughout the experiment. Constant illumination was under a 100-watt bulb at 4 feet. The "normal" diurnal cycle was one of 14 hours of daylight and 10 of darkness.

MARTHA D. BERLINER

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References and Notes

1. E. N. Harvey, *Bioluminescence* (Academic Press, New York, 1952).
2. J. W. Hastings, *Ann. Rev. Microbiol.* **13**, 297 (1959).
3. ———, in *Photoperiodism,* R. B. Winthrow, Ed. (AAAS, Washington, D.C., 1959).
4. The cultures of *Panus stipticus* and *Armillaria mellea* were supplied by Dr. Ruth Macrae, and that of *Mycena polygramma* by the Central Bureau voor Schimmelculture.

5 June 1961

Meetings

Forthcoming Events

October

7–13. American Soc. of Oral Surgeons, 43rd annual, New York–Bermuda cruise, *M.S. Bergensfjord.* (D. C. Trexler, ASOS, 840 N. Lake Shore Drive, Chicago 11, Ill.)

9–12. Water Pollution Control Federation, 34th annual, Milwaukee, Wis. (R. E. Fuhrman, 4435 Wisconsin Ave., NW, Washington 16)

9–13. American Rocket Soc., space flight meeting, New York, N.Y. (ARS, 500 Fifth Ave., New York 36)

9–13. Luminescence of Inorganic and Organic Systems, intern. conf., New York, N.Y. (Miss G. M. Spruch, New York Univ., Washington Sq., New York 3)

10–12. Nuclear Reactor Chemistry, 2nd conf., and Analytical Chemistry in Nuclear Reactor Technology, 5th conf., Gatlinburg, Tenn. (Oak Ridge National Laboratory, Post Office Box X, Oak Ridge, Tenn.)

10–13. Administration of Research, 15th conf., San Juan, Puerto Rico. (G. F. Anton, Research Center, Univ. of Puerto Rico, Mayaguez, P.R.)

10–20. International Committee for Biological Control, Tunis. [P. Grison, Laboratoire de Biocenotique et de Lutte Biologique, La Miniere, par Versailles (S.-et.-O.), France]

11–13. Gaseous Electronics Conf., American Physical Soc., Schenectady, N.Y. (C. J. Gallagher, General Electric Research Laboratories, Schenectady, N.Y.)

11–14. Tau Beta Pi Assoc., Cincinnati, Ohio. (R. H. Nagel, Univ. of Tennessee, Knoxville)

11–14. Western Inst. on Epilepsy, 13th annual conf., San Antonio, Tex. (F. Risch, 3097 Manning Ave., Los Angeles, Calif.)

12–13. Congress of Neurological Surgeons, New York, N.Y. (E. Weiford, 4706 Broadway, Kansas City 12, Mo.)

12–29. Pacific Intern. Trade Fair, 2nd, technical meetings, Lima, Peru. (PITF, P.O. Box 4900, Lima)

14–20. International Congr. of Neurological Surgery, 2nd, Washington, D.C. (B. S. Ray, 525 E. 68 St., New York 21)

15. American College of Dentists, Philadelphia, Pa. (O. W. Brandhorst, 4236 Lindell Blvd., St. Louis, Mo.)

15–20. American Inst. of Electrical Engineers, fall general meeting, Detroit, Mich. (E. C. Day, AIEE, 33 W. 39 St., New York 18)

15–20. International Congr. of Allergolgy, 4th, New York, N.Y. (W. B. Sherman, 60 E. 58 St., New York 22)

15–21. Pan American Congr. of Endocrinology, 5th, Lima, Peru. (M. San Martin, Av. Central 325, San Isidoro, Lima)

16–17. Engineering Writing and Speech, natl. symp., East Lansing, Mich. (J. D. Chapline, Philco Corp., 3900 Welsh Rd., Willow Grove, Pa.)

16–17. Ionization of the Air, intern. conf., Philadelphia, Pa. (I. C. Kornblueh, American Inst. of Medical Climatology, 1618 Allengrove St., Philadelphia 24)

16–18. American Soc., of Safety Engineers, Chicago, Ill. (A. C. Blackman, 5 N. Wabash Ave., Chicago 2)

16–18. Entomological Soc. of Canada and Entomological Soc. of Quebec, Quebec, Canada. (L. L. Reed, ESC, Neatby Bldg., Carling Ave., Ottawa, Canada)

16–18. Metallurgy of Beryllium, intern. conf., London, England. (Secretary, Inst. of Metals, 17 Belgrave Sq., London, S.W.1)

16–19. American Dental Assoc., Philadelphia, Pa. (H. Hillenbrand, 222 E. Superior St., Chicago 11, Ill.)

16–19. Vacuum Science and Technology, 2nd intern. congr., Washington, D.C. (W. M. Welch, Intern. Organization for Vacuum Science and Technology, 1515 Sedgwick St., Chicago 10, Ill.)

16–20. American Ornithologists' Union, Washington, D.C. (H. G. Deignan, U.S. National Museum, Washington 25)

16–20. American Soc. of Civil Engineers, New York, N.Y. (W. H. Wisely, 33 W. 39 St., New York 18)

16–20. Symposium on the Programming and Utilization of Research Reactors, Vienna, Austria. (Intern. Atomic Energy Agency, Room 2249, United Nations, New York, N.Y.)

17–19. Japan Conf. of Radioisotopes, 4th, Tokyo. (R. Suga, Japan Atomic Industrial Forum, Inc., No. 1, 1-Chome, Shiba Tamura-cho, Minato-ku, Tokyo)

17–19. Lubrication Conf., 8th, jointly by American Soc. of Lubrication Engineers and American Soc. of Mathematical Engineers, Chicago, Ill. (R. L. Johnson, NASA, Lewis Research Center, 21000 Brookpark Rd., Cleveland 35, Ohio)

18–20. Design of Experiments in Army Research, Development, and Testing, 7th conf. (by invitation only), Fort Monmouth, N.J. (F. G. Dressel, Army Research Office (Durham), Box CM, Duke Station, Durham, N.C.)

18–20. Optical Soc. of America, Los Angeles, Calif. (Miss M. E. Warga, 1155 16 St., NW, Washington 6)

19–20. International Geophysics Assoc., 12th colloquium, Salzburg, Austria. (IGA, Freisaalgasse 31, Salzburg)

19–21. Indiana Acad. of Science, Terre Haute. (E. D. Weinberg, Dept. of Bacteriology, Indiana Univ., Bloomington)

20–21. Shallow Water Research Conf., Atlantic Coast, 1st natl., Baltimore, Md. (D. S. Gorsline, Oceanographic Inst., Florida State Univ., Tallahassee)

20–24. American Heart Assoc., annual, Miami Beach, Fla. (AHA, 44 E. 23 St., New York 10)

23–25. International Scientific Radio Union and Inst. of Radio Engineers, fall meeting, Austin, Tex. (Miss H. E. Hart, U.S.A. Natl. Committee URSI, 2101 Constitution Ave., NW, Washington 25)

23–25. Metallurgical Soc. of the American Inst. of Mining, Metallurgical and Petroleum Engineers, fall meeting, Detroit, Mich. (AIME, 29 W. 39 St., New York 18)

23–27. Metal Congr. and Exposition, 43rd natl., Detroit, Mich. (A. R. Putnam, American Soc. for Metals, Metals Park, Novelty, Ohio)

23–28. Congress of Chemical Engineering, 1st, San Juan, P.R. (R. Munoz, Apartado 47, Estación de Río Piedras, San Juan)

24–25. Shallow Water Research Conf., Gulf Coast, 1st natl., Tallahassee, Fla. (D. S. Gorsline, Oceanographic Inst., Florida State Univ., Tallahassee)

24–26. Aerospace Nuclear Propulsion, intern. symp., Las Vegas, Nev. (P. M. Uthe, Lawrence Radiation Laboratory, Univ. of California, Box 808, Livermore)

24–27. American Dietetic Assoc., 44th annual, St. Louis, Mo. (Mrs. T. Pollen, ADA, 620 N. Michigan Ave., Chicago 11, Ill.)

26–27. American Soc. of Tool and Manufacturing Engineers, Toronto, Canada. (A. Cervenka, Vanderbilt Blvd., Oakdale, L.I., N.Y.)

26–27. Instrumentation Facilities for Biomedical Research, symp., Omaha, Neb. (H. G. Beenken, Univ. of Nebraska College of Medicine, 42 and Dewey Ave., Omaha)

26–27. New Mexico Acad. of Science, Albuquerque. (K. G. Melgaard, P.O. Box 546, Mesilla Park, N.M.)

26–28. Professional Group on Electron Devices, annual meeting, Washington, D.C. (I. M. Ross, Technical Program Chairman, Room 2A-329, Bell Telephone Laboratories, Murray Hill, N.J.)

26–30. American Soc. for Aesthetics, Detroit, Mich. (J. R. Johnson, Cleveland Museum of Art, Cleveland 6, Ohio)

27–28. Shallow Water Research Conf., Pacific Coast, 1st natl., Los Angeles, Calif. (D. S. Gorsline, Oceanographic Inst., Florida State Univ., Tallahassee)

27–29. Association of Clinical Scientists, annual, Washington, D.C. (R. P. MacFate, Secretary, ACS, 323 Northwood Rd., Riverside, Ill.)

28. American Mathematical Soc., 583rd meeting, Cambridge, Mass. (E. Pitcher, Lehigh Univ., Bethlehem, Pa.)

29–31. Photoelasticity, intern. symp., Chicago, Ill. (P. D. Flynn, Illinois Inst. of Technology, Chicago 16)

29–1. Marine Biology, intern. conf. (by invitation only), Princeton, N.J. (Mrs. E. Purcell, Interdisciplinary Conference Program, Rockefeller Center, Time & Life Bldg., New York 20)

30–1. American Oil Chemists Soc., Chicago, Ill. (W. O. Lundberg, Hormel Inst., Univ. of Minnesota, 801 16th Ave., NE, Austin)

30–1. Society of Rheology, annual, Madison, Wis. (J. D. Ferry, Univ. of Wisconsin, Madison)

31–2. Interscience Conf. on Antimicrobial Agents and Chemotherapy, 1st, American Soc. for Microbiology, New York, N.Y. (ASM, 19875 Mack Ave., Detroit 36, Mich.)

November

1. Rheumatic Fever, symp., New Haven, Conn. (E. A. Sillman, Connecticut Heart Assoc., 65 Wethersfield Ave., Hartford 14)

1–3. Alkaline Pulping, 15th conf., Houston, Tex. (Technical Assoc. of the Pulp and Paper Industry, 360 Lexington Ave., New York 17)

1–3. Experimental Mechanics, 1st intern. congr., New York, N.Y. (Soc. for Experimental Stress Analysis, P.O. Box 168, Central Sq. Station, Cambridge 39, Mass.)

1–3. High Magnetic Fields, intern. conf., Cambridge, Mass. (H. H. Kolm, Lincoln Laboratory, Massachusetts Inst. of Technology, Lexington 73)

1–3. Transplantation, CIBA Foundation symp. (by invitation), London, England. (CIBA Foundation, 41 Portland Pl., London, W.1)

1–4. American Soc. of Tropical Medicine and Hygiene, Washington, D.C. (R. B. Hill, 3575 St. Gaudens Rd., Miami 33, Fla.)

1–4. Society of Economic Geologists, Cincinnati, Ohio. (E. N. Cameron, Science Hall, Univ. of Wisconsin, Madison 8)

2–3. Cancer Chemotherapy, clinical symp., Washington, D.C. (T. P. Waalkes, Chemotherapy Natl. Service Center, NIH, Bethesda 14, Md.)

2–4. American Soc. for Cell Biology, 1st, Chicago, Ill. (H. Swift, Dept. of Zoology, Univ. of Chicago, Chicago 37)

2–4. Geochemical Soc., Cincinnati, Ohio. (F. R. Boyd, Jr., Geophysical Laboratory, 2801 Upton St., NW, Washington 8)

2–4. Geological Soc. of America, Cincinnati, Ohio. (F. Betz, Jr., GSA, 419 W. 117 St., New York 27)

2–4. Inter-Society Cytology Council, annual, Memphis, Tenn. (P. A. Younge, 1101 Beacon St., Brookline 46, Mass.)

2–4. National Assoc. of Geology Teachers, Cincinnati, Ohio. (D. J. Gare, Principia College, Elsah, Ill.)

2–4. Paleontological Soc., Cincinnati, Ohio. (H. B. Whittington, MCZ, Harvard Univ., Cambridge 38, Mass.)

2–4. Society for Industrial and Applied Mathematics, Washington, D.C. (Chairman, Program Committee, SIAM, P.O. Box 7541, Philadelphia 1, Pa.)

2–5. Mathematical Models in the Social and Behavioral Sciences, conf., Cambria, Calif. (F. Massarik or P. Ratoosh, Mathematical Models Conf., Graduate School of Business Administration, Univ. of California, Los Angeles 24)

3–4. Central Soc. for Clinical Research, Chicago Ill. (J. F. Hammarsten, Veterans Administration Hospital, 921 N.E. 13 St., Oklahoma City 4, Okla.)

4. Society for the Scientific Study of Sex, New York, N.Y. (H. G. Beigel, 138 E. 94 St., New York 28)

5–8. American Speech and Hearing Assoc., Chicago, Ill. (K. O. Johnson, 1001 Connecticut Ave., NW, Washington 6)

5–9. Society of Exploration Geophysicists, 31st annual intern., Denver, Colo. (C. C. Campbell, Box 1536, Tulsa 1, Okla.)

5–11. Stomatology of Peru, intern. congr., Lima, Peru. (A. Rojas, Avenue Pershing 155, San Isidro, Lima)

5–15. Japanese Chemical Engineers Soc., 25th anniversary congr., Tokyo and Kyoto, Japan. (Kagaku-Kogaku Kyokai, Shunichi Uchida, 609 Kojunsha Bldg. No. 4, 6-Chome, Ginza, Chou-Ku, Tokyo)

5–18. Latin American Phytotechnical Meeting, 5th, Buenos Aires, Argentina. (U. C. Garcia, Rivadavia 1439, Buenos Aires)

6–8. Association of Military Surgeons of the U.S., 68th annual, Washington, D.C. (R. E. Bitner, AMSUS, 1726 Eye St., NW, Washington 6)

6–8. Cell in Mitosis, 1st annual symp., Detroit, Mich. (L. Levine, Dept. of Biology, Life Sciences Research Center, Wayne State Univ., Detroit 2)

6–9. Atomic Industrial Forum–9th Hot Laboratories and Equipment Conf., Chicago, Ill. (O. J. Du Temple, American Nuclear Soc., 86 E. Randolph St., Chicago)

6–9. Southern Medical Assoc., Dallas, Tex. (R. F. Butts, 2601 Highland Ave., Birmingham 5, Ala.)

8. American Acad. of Arts and Sciences, Brookline, Mass. (J. L. Oncley, 280 Newton St., Brookline 46)

8–10. Nondestructive Testing in Electrical Engineering, conf., London, England. (Secretary, Institution of Electrical Engineers, London W.C.2)

8–11. Acoustical Soc. of America, Cincinnati, Ohio. (W. Waterfall, American Inst. of Physics, 335 E. 45 St., New York 17)

8–11. Institute of Management Sciences, San Francisco, Calif. (W. Smith, Inst. of Science & Technology, Univ. of Michigan, Ann Arbor)

8–11. Plasma Physics, American Physical Soc., 3rd annual, Colorado Springs, Colo. (F. Ribe, Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, N.M.)

9–10. Operations Research Soc. of America, 20th, San Francisco, Calif. (P. Stillson, 115 Grove Lane, Walnut Creek, Calif.)

9–11. Gerontological Soc., Pittsburgh, Pa. (R. W. Kleemeier, Washington Univ., Skinker and Lindell, St. Louis 30, Mo.)

9–12. Pacific Coast Fertility Soc., Palm Springs, Calif. (G. Smith, 909 Hyde St., San Francisco 9, Calif.)

9–20. Photography, Cinematography, and Optics, 3rd intern. biennial, Paris, France. (Comité Francais des Expositions, 15 rue de Bellechasse, Paris 7)

12–17. Bahamas Conf. on Medical and Biological Problems in Space Flight, Nassau, Bahamas. (I. M. Wechsler, P.O. Box 1454, Nassau)

13–14. Exploding Wire Phenomenon, 2nd intern. conf., Boston, Mass. (W. G. Chace, Thermal Radiation Laboratory, CRZCM, Geophysics Research Directorate Air Force Cambridge Research Laboratories, Bedford, Mass.)

13–16. Magnetism and Magnetic Materials, 7th annual intern. conf., Phoenix, Ariz. (P. B. Myers, Motorola, Inc., 5005 E. McDowell Rd., Phoenix 10)

13–17. American Public Health Assoc., 89th annual, New York, N.Y. (APHA, 1790 Broadway, New York)

13–17. Gulf and Caribbean Fisheries Inst., 14th annual, Miami Beach, Fla. (J. B. Higman, Marine Laboratory, Univ. of Miami, 1 Rickenbacker Causeway, Virginia Key, Miami 49)

13–18. European Conf. on the Control of Communicable Eye Diseases, Istanbul, Turkey. (World Health Organization, Palais des Nations, Geneva, Switzerland)

14–16. American Meteorological Soc., Tallahassee, Fla. (Executive Secretary, AMS, 45 Beacon St., Boston 8, Mass.)

14–17. Corrosion in Nuclear Technology, symp., Paris, France. (European Federation of Corrosion, Société de Chimie Industriells, 28 rue St. Dominique, Paris 7e)

14–18. Puerto Rico Medical Assoc., Santurce. (J. A. Sanchez, P.O. Box 9111, Santurce)

15–17. Eastern Analytical Symp., New York, N.Y. (A. Rekus, EAS, Research Dept., Baltimore Gas & Electric Co., Pratt St., Baltimore, Md.)

15–18. Society of Naval Architects and Marine Engineers, annual, New York, N.Y. (W. N. Landers, SNAME, 74 Trinity Pl., New York 6)

16–18. American Psychiatric Assoc., Milwaukee, Wis. (J. D. McGucken, 756 N. Milwaukee St., Milwaukee 2)

16–18. Etiology of Myocardial Infarction, intern. symp. (by invitation), Detroit, Mich. (T. N. James, Section on Cardiovascular Research, Henry Ford Hospital, Detroit)

16–18. Southern Thoracic Surgical Assoc., Memphis, Tenn. (H. H. Seiler, 517 Bayshore, Blvd., Tampa 6, Fla.)

16–19. American Anthropological Assoc., Philadelphia, Pa. (S. T. Boggs, 1530 P St., NW, Washington, D.C.)

17–18. Southern Soc. for Pediatric Research, Atlanta, Ga. (W. G. Thurman, Dept. of Pediatrics, Emory Univ. School of Medicine, Atlanta)

17–31. National Soc. for Crippled Children and Adults, annual conv., Denver, Colo. (NSCCA, 2023 W. Ogden Ave., Chicago 12, Ill.)

19–22. International College of Surgeons, Western regional, San Francisco, Calif. (W. F. James, 1516 Lake Shore Drive, Chicago 10, Ill.)

22–27. Automation and Instrumentation, 5th conf., Milan, Italy. (Federezione delle Societa Scientifiche e Techniche di Milano, via S. Tomaso 3, Milan)

22–1. Radioisotopes in Animal Biology and the Medical Sciences, conf., Mexico City, D.F. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1, Austria)

23–25. Central Assoc. of Science and Mathematics Teachers, Chicago, Ill. (J. Kennedy, Indiana State Teachers College, Terre Haute)

24–25. American Soc. of Animal Production, Chicago, Ill. (C. E. Terrill, Animal Husbandry Research Div., U.S. Dept. of Agriculture, Beltsville, Md.)

24–25. National Council for Geographic Education, Philadelphia, Pa. (L. Kennamer, Dept. of Geography, Univ. of Texas, Austin)

25–26. American College of Chest Physicians, annual interim session, Denver, Colo. (M. Kornfeld, ACCP, 112 E. Chestnut St., Chicago 11, Ill.)

26. Medical Aspects of Sports, 3rd natl. conf., Denver, Colo. (F. V. Hein, AMA Committee on the Medical Aspects of Sports, 535 N. Dearborn St., Chicago 10, Ill.)

26–1. American Soc. of Mechanical Engineers, winter, New York, N.Y. (L. S. Dennegar, ASME, 29 W. 39 St., New York)

26–1. Radiological Soc. of North America, annual, Chicago, Ill. (R. P. Barden, 713 E. Genesee St., Syracuse 2, N.Y.)

27–28. Agricultural Meteorology, 4th conf., St. Louis, Mo. (K. C. Spengler, American Meteorological Soc., 45 Beacon St., Boston 8, Mass.)

27–29. American Soc. of Hematology, annual, Los Angeles, Calif. (J. W. Rebuck, ASH, Henry Ford Hospital, Detroit 2, Mich.)

27–30. American Medical Assoc., Denver, Colo. (F. J. L. Blasingame, 535 N. Dearborn, Chicago 10, Ill.)

27–30. Entomological Soc. of America, Miami, Fla. (R. H. Nelson, 4603 Calvert Rd., College Park, Md.)

PERSONNEL PLACEMENT

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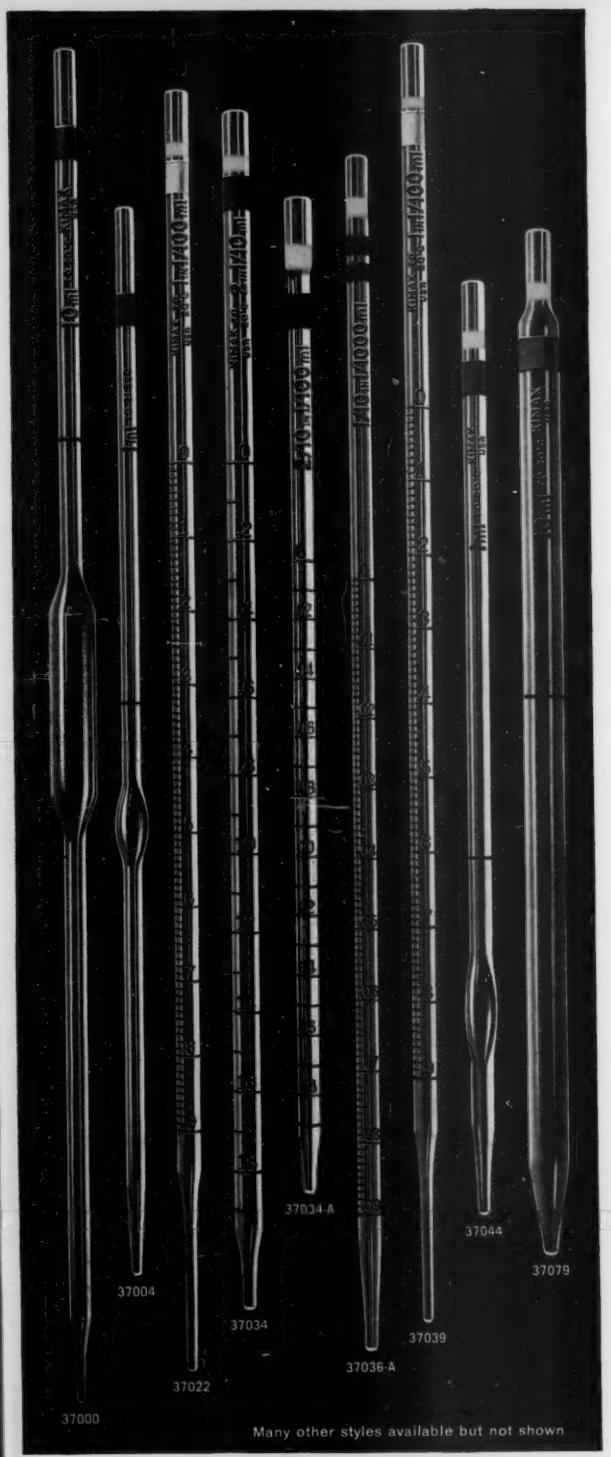

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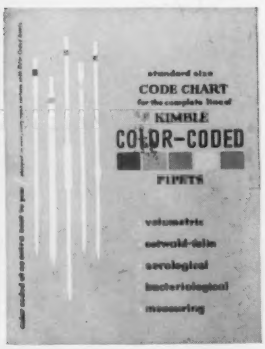

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